INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

MAY 1960

CONTENTS: 2 AD INDEX: 4

ONE DOLLAR PER COPY

WHERE DO WE GO FROM HERE?

Confronted by change and expansion our industry is feeling out new paths to progress — Annual reports of 75 companies spell out the trends of the Sixties.

PERFORATE CASING OR CLEAN UP THE HOLE WITH THIS NEW DOWELL IDEA--ABRASIJET

You see here a new tool, designed to help you get better wells, being readied for a trip down the hole. This tool is the principal feature of Abrasijet*, Dowell's fast, effective abrasive jetting service. This new service—using fluid and abrasive particles as the cutting medium—makes quick work of cleaning formation faces or casing. It is used to enlarge well bore diameters and to perforate casing *without explosives*. The fact is—operators are finding new, important uses for Abrasijet every day. By itself, Abrasijet is an important addition to the services that help you make your wells worth more. As part of the varied services offered by Dowell, Abrasijet symbolizes the new ideas you have come to expect from Dowell—*first*. Another example that you get more for your money when you *dial Dowell*. Dowell, Tulsa 1, Oklahoma.

*Dowell Service Mark

Services for the oil industry

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

at presstime . . . *a last minute round-up of petroleum industry news*

Mandatory change or else is keynote of survival today. When hard pressed in the past, industry was aided by external events: World War II; Korea; the Suez Crisis. Nothing is in sight now; we must make our own changes. Opportunities exist in research, foreign activity, expansion of markets, growth in petrochemicals, in natural gas and balanced operations. Some changes indicated by increased expenditures for 1960. Domestic budgets up 4 percent over 1959 to $5.8 billion; foreign spending will be up 6 percent.

Drilling is on the upswing according to April 18 Hughes Tool rig count of rotaries actually making hole. U.S. total was 1829 rigs — highest this year. A year ago, U.S. rotary count was 2081. Canada started the year (Feb. 22) with 255 rotaries; dropped to 101 in April 18 tally. Look for continued climb in U.S. Average for year expected to be 2000 rigs.

Canada OK's U.S. gas imports totaling more than a billion cu ft per day to open the way for construction of some 2100 miles of big-diameter pipelines on both sides of border. Few of the proposals await FPC and California Public Utilities Commission approval. Construction to be about $443 million; Canada to get about $1.85 billion over 25-year contract; and some 1000 shut-in gas wells in Alberta will be affected.

Heavy gasoline consumption season is on and refiners are getting set, judging by upturn in crude runs, which topped 8 million bbl daily for first time since February. This was 81.1 percent of capacity, according to API. Total U.S. inventories of gasoline, kerosine, distillates and fuels were down 13¼ million bbl from previous week, but 47.4 million bbl above a desirable level for the start of April.

Crude oil prices take another break amidst protests from independent producers and threats of state anti-trust investigations. Texas, producer of over one-third the nation's oil, took more price cuts in the staunch East Texas field where three different postings now prevail. Both North and North Central Texas bowed under cuts of recent date. Regional effects on economy may restore some cutback, but most will stick. Texas' Governor Daniel asked attorney general to check for possible anti-trust violations.

Use extreme caution in private industry contacts with government officials. Remember how proposed revisions of the Natural Gas Act were killed. Now slated for hearings by Legislative Oversight subcommittee, major pipeline companies will be examined to determine extent, if any, of off-the-record contacts with FPC in rate cases.

Gulf files imports suit charging that Secretary of Interior failed to allot fairly and equitably residual fuel imports. It asked a federal court to nullify method of fixing allocations as part of the Administration's import policy. Gulf said present order "has the effect of freezing all importers to their proportions of the total fuel oil imports in 1957 without regard to changed circumstances thereafter."

To prorate or not to prorate waterfloods has been argued at technical meetings and in the literature. In Texas, where some 365 fields are exempt from deep proration cuts due to stripper or waterflood status, the Texas Railroad Commission will begin hearings June 16 at Austin. It's a technical question. Some think proration of waterfloods will result in underground loss; others think not. And both have data to prove their respective points.

Delhi-Taylor abandons second Australian wildcat, the Delhi-Frome-Santos Betoota No. 1 located in Queensland, after reaching 9824 ft. Operator reports it is unlikely oil accumulations will be found below this depth. The first wildcat located about 130 miles south sought production on flank of what many consider largest structure on continent. It, too, was abandoned. Another location will be staked upon conclusion of current seismic, surface and subsurface geologic work.

THE PETROLEUM Engineer

FOR MANAGEMENT

NUMBER 5 • VOLUME XXXII • MAY, 1960

The Conference Table A-10

"Don't look back, somebody may be gaining on you."
— *Satchel Paige*

Where Do We Go From Here? A-21

13th Annual Report Survey shows 1959 was better than you think — Changes are indicated by broad new trends.
— *Ernestine Adams*

Speaking Your Way to Success A-34

Another of the "How to be a Manager" series.
— *Orville Roberts, Jr.*

The Tortured Genius Who Invented the Diesel A-36a
— *Jim Moore*

E SECTION FOLLOWS A

Effective Leadership Induces Creative Group Thinking E-4

"Do it yourself projects" for determining employees' and supervisors' opinions, may be more economical than hiring a consulting firm. — *Carl Mullins White*

10-Way Communications E-8

Here's a formula for checking your communications rating ... and the way to get back in balance if you're stressing one factor too much. — *Thomas Garcia-Barras*

At Presstime A-1
Advertisers' Index A-4
The Course of Oil A-6
Petroleum Profile A-8
Ralph A. Johnston
The Conference Table A-10
Management Personals E-14
Books to Read E-22
Meetings E-25
Laugh with Barney E-25
Of Things To Come in Oil ... E-3
Running Tour with Men in the Industry B-104
New Drilling and Producing Equipment B-112
New Drilling and Producing Literature B-127
The Oasis B-132
What's Doing in Drilling ... B-134
Exploration Activities B-138
Suppliers' Parade B-143
Books to Read B-145
Construction Briefs C-3
New Equipment C-63
New Literature C-65
Petro/Chem Newsmakers ... C-68
Pipeline Projects D-64
With the Pipeline Contractors D-72
Pipeline Personals D-75
Pipeline Parade D-77
New Pipeline Equipment D-79
New Pipeline Literature D-82

Copyright 1960 The Petroleum Engineer Publishing Company

Indexed by
Applied Science and Technology Index,
The Engineering Index, Inc. and Chemical Abstracts
Member of Audit Bureau of Circulation
and Associated Business Publications

The Petroleum Engineer for Management, published monthly, August through June, semi-monthly in July by The Petroleum Engineer Publishing Company, 800 Davis Building, Dallas 2, Texas. Subscription rate to the petroleum industry, United States, Canada, and foreign, $4.00 per year; $7.00 for 2 years; $9.00 for 3 years; $1.00 for single copy. Entered as second-class mail matter May 1, 1932, at the post office in Dallas, Texas, under the act of March 3, 1879. Please send subscription correspondence and change of address to The Petroleum Engineer Publishing Company, P. O. Box 1589, Dallas 21, Texas. Subscribers should notify publisher promptly of any change of address, giving old as well as new address, and including city postal delivery zone, if any. If possible, enclose an address label from a recent issue of the magazine. Allow one month to six weeks for change to become effective.

NOTE: Payments from outside the U. S. A. may be made by international money order, New York exchange, check on a U. S. A. bank, UNESCO coupons, or write us for name of nearest representative who can handle your order in the currency of your country.

DRILLING AND PRODUCING

World's Deepest Ultra-Slim Hole Is Ultra Hot B-19
— *Floyd Newlin and J. E. Kastrop*

Quick Methods of Oil-Reservoir Analysis B-27
— *R. V. Higgins*

Secondary Recovery Booms in Western Nebraska B-34
— *H. N. Rhodes*

Make Your Drillstem Test A Success B-40
— *G. E. Wilson and J. R. Holmes*

API Meetings Highlighted B-44

Waterflood Curtailment — Pro and Con B-48
— *Donald E. Menzie and Frank W. Cole*

AOSC Holds Directors Meeting in Dallas B-68

Modern Well Completion Series
Part 6: How to Design and Run Casing Strings B-72
J. F. Hendrickson

Simplified Log Interpretation, Part 1 ..... B-90
— *Terry Walker*

Downhole Flowmeter Pinpoints Flow B-102

Glass Capsules Aid Sick Wells B-142

PETRO/CHEM ENGINEER

Unicracking: A Modern and Versatile Hydrocracking Process C-6
— *R. C. Hansford, C. P. Reeg, F. C. Wood and Raoul Vaell*

Hydrogen Processing in Modern Refining C-13
— *C. E. Slyngstad and F. L. Lempert*

Gulfining No. 2 Fuel Oil Distillates C-19
— *W. A. Horn, J. D. McKinney and T. Rice*

Hydrogenation of Catalytic Cracking Feedstocks C-25
— *C. C. Williams and M. D. Abbott*

Process Notebook C-35

API's "College of Refining" C-37

Mathematics Workshop C-41

Refinery Construction Manual, Part 12 ..... C-43
— *Henry Martyn Noel*

Performance Tests: They Can Save You Money C-46
— *R. H. Parekh*

OIL AND GAS PIPELINING

One-Man System Operation D-19
— *M. M. Levy*

Operation Curves Developed for Natural Gas Compressors D-22
— *Henry B. Morich, Jr. and Jack T. Watzke*

Calculation of Reciprocating Compressor Performance Data D-26
— *R. L. Ridings*

Maximum Profit with Minimum Investment D-30
— *Alva C. Smith*

Gas Storage at 5000 Psi D-37
— *Floyd Trillis*

Fault Analyzer Pinpoints Wireline Trouble D-44

Products Delivered Automatically with Gravitometer D-46
— *Henry A. Brainerd and Robert N. Warren*

First Things First in Automation D-54
— *Harry G. Schad*

Transistorized Carrier and Multiplex Systems, Part 2 ..... D-56
— *T. T. Wagner, Jr.*

Special Catch Joint for Off-Stream Line Cleaning D-60

Pipeline Fundamentals
Underground Corrosion and Methods of Control, Part 4 ..... D-61
— *O. C. Mudd*

Pipeline Communication and Control
Small Transmitter Tubes Tested by New Method D-74a
— *Thomas H. Briggs*

Joe B. Woods
President and Publisher
Abbott Sparks
Vice President and Advertising Director
E. V. Perkins
Vice President and Western Manager
J. E. Kastrop
Editorial Director
L. H. Johnston
Secretary-Treasurer
Roland D. Carpenter
Controller

•

Ernestine Adams
Management Editor
Jack W. Williamson
Editor, Drilling and Producing
Frank H. Love
Editor, Pipeline Engineer
J. C. Webb, Jr.
Editor, Petro/Chem Engineer
Lowell A. Murphy
Assistant Editor, Drilling and Producing
Walter A. Hogan
Field Editor
Jan Craig
Editorial Production Manager
Lynn Patton
Editorial Assistant
Donald D. Pickert
Presentation Editor

•

NEW YORK — John L. McDonald
52 Vanderbilt Ave., MUrray Hill 6-7232
CHICAGO — E. V. Perkins
H. G. Fitzpatrick
53 West Jackson Blvd., HArrison 7-6883
LOS ANGELES — Richard P. McKay
Bruce Berkey
465 Converse Place, Pasadena
MUrray 1-0685
CLEVELAND — G. A. Warren
1010 Rockwell Ave., TOwer 1-4231
HOUSTON — Jess Adkins
2370 Rice Blvd., Room 110, JAckson 6-3631
DALLAS — Ed Sealey
Paul J. Mansfield
800 Davis Building, Riverside 8-4403
BIRMINGHAM — Fred W. Smith
1201 Forest View Lane, Vestavia
TRemont 1-5752
UNITED KINGDOM—Kenneth S. Brooks
43 Blandford St., London, W. 1.
WESTERN GERMANY-HOLLAND —
Norbert Woelfl
Lohernockenstrasse 18,
Ennepetal-Voerde, Germany

•

Allen K. Tyler
Production Manager
Jack H. Selby
Assistant Production Manager
Glen D. Hebert
Advertiser Services Manager
Charles McKean
Circulation Director
Royal Courtney
Circulation Fulfillment Manager
Sherwood R. Entwistle
Circulation Promotion Manager
Harold L. Seamans
Circulation Field Service Manager

Cable Address: PEPUB

Highlights and footnotes

Market Forecast. Amount of domestic crude oil to be consumed or exported in May 1960 is estimated by the Bureau of Mines at 6,620,000 b/d. This is 6.9% more than the forecast for April 1960, but is 7.2% under actual demand for May 1959.

Occidental Grows. Occidental Petroleum has won control of Parker Petroleum, Ponca City, Oklahoma and previous to that had taken control of Gene Reid Drilling, Bakersfield, California. Dr. Armand Hammer is president of Occidental, a California firm.

Allowables Cut. Texas Railroad Commission set an 8-day oil flow for the state in May, one day less than April. This was recommended by most purchasers.

Award for Phillips. National Society of Professional Engineers presented its first annual Industrial Professional Development Award to Phillips Petroleum for "outstanding advancement and improvement in the development and application of forward-looking engineering employment practices."

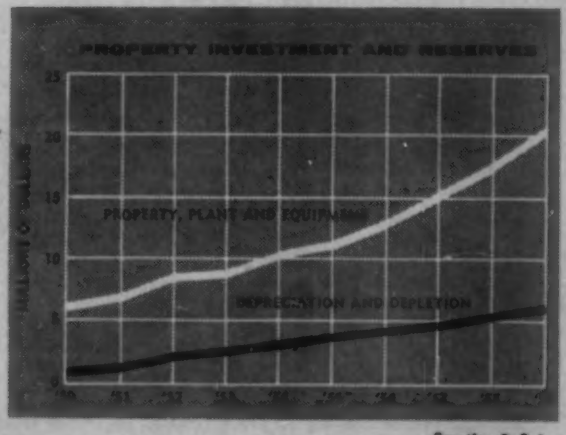
Feud Hits Oil. The Venezuelan Government released a statement that police action had smashed a plot for frog-men trained in the Dominican Republic to place demolition charges under the waters of Lake Maracaibo. About 80 percent of Venezuela's oil comes from Maracaibo fields. Generalissimo Trujillo, the Dominican dictator, is a bitter foe of Venezuela's President Betancourt.

S. A. Common Market. Eight Latin American countries have negotiated an agreement to create gradually a free trading zone covering most of South America and Mexico. The agreement calls for eventual abolition over a 12-year period of tariffs and custom barriers on most goods traded among these nations: Brazil, Argentina, Chile, Peru, Bolivia, Paraguay, Uruguay and Mexico. Central American countries are considering a similar plan.

European Congress. The fourth European Congress on Petroleum Equipment in Paris, 22-25 June 1960. The program covers all phases of operations and their equipment. Part of them are in English. Secretary of the Committee is M. Le Gall, 15 rue Beaujon, Paris 8, France.

More Fuel Oil. Interior Secretary Seaton announced that from April 1 through June 30 residual fuel oil imports will be up 12,000,000 bbl. This brings the total amount for imports in the second quarter to about 30¼ million bbl. Cold weather in March brought the change.

NPR's Obsolete. The Director of the Naval Petroleum Reserves is willing to abandon NPR No. 4 in Alaska and to lease the one in Wyoming. At the same time he wants to establish a new naval reserve on San Nicolas Island off Southern California. Why the navy should be developing petroleum reserves is still a great mystery. President Eisenhower has urged Congress to end all NPR's. He called them "anachronistic."



Inadequacy of depreciation and depletion deductions is shown in this chart from Frontier's annual report. See page A-21 for analysis of reports from 75 petroleum companies.

Frontier Refining

ADVERTISERS' INDEX

— A —

ACF Industries, Incorporated — W-K-M Division A-36a, B-6, C-2
Ajax Iron Works B-8
Allen-Bradley Co. E-13
Allis-Chalmers D-68, D-69
The American Brass Company C-59
American Machine and Foundry Company, The J. B. Beaird Company, Incorporated, Subsidiary E-10
American Meter Company A-17, E-14
American Petroleum Institute E-9
American Steel and Wire Division of United States Steel E-2, E-3
Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division D-56
Armour Industrial Chemical Company, Division of Armour and Company B-12, B-13
Arno Adhesive Tapes, Inc. D-82
Automatic Electric, Subsidiary of General Telephone & Electronics D-45
Axelson Manufacturing Company, Division of U. S. Industries, Inc. B-94

— B —

Bausch-Ross Division of Jay Manufacturing Company B-113
The Babcock & Wilcox Company, Tubular Products Division C-42
Baker Oil Tools, Inc. B-18, B-42, B-43
Baroid Division, National Lead Co. B-39, B-92, B-93
The J. B. Beaird Company, Incorporated, Subsidiary, American Machine and Foundry Company E-10
Bethlehem Steel Company D-4, D-5
Bethlehem Steel Company, Supply Division B-116
Black, Sivalls & Bryson, Inc. A-19
Brakeol, Inc. B-142
Bradford Motor Works B-10
Brown Oil Tools, Inc. B-83

— C —

Cabot Shops, Inc. B-1
Cameron Iron Works B-115
Chase & Sons, Inc., Carr-Prev Division D-76
Clark Bros. Co. D-74b, D-74c
The Cleveland Trencher Co. D-8
Climax Engine Manufacturing Co., Division of Waukesha Motor Co. B-81
The Colorado Fuel and Iron Corporation B-49
Conco Chemical Co. D-44
Continental-Emsco Company, a Division of The Youngstown Sheet and Tube Company B-59, B-60, B-61, B-62, B-63, B-64
Continental Oil Company B-105
Core Laboratories, Inc. B-139
Crane Packing Company D-75
Crane-Perrault Equipment Corp. D-47
The Cresset Chemical Company, Chemical Division B-145
Crutcher-Rolfs-Cummings D-71

— D —

Daniel Orifice Fitting Company, Incorporated E-23
Darling Valve & Manufacturing Co. D-70
Degussa-Hanau C-45
Dempster Brothers, Inc. A-18
Diamond Chain Company, Inc. B-132, B-133
Dodge Manufacturing Corporation B-110
Dowell ..... Inside Front Cover, A-11
Du Pont, E. I., de Nemours & Co., Inc. A-36g, C-53, C-54
Duremetallic Corporation C-65
The Duriron Company, Inc. D-39

— E —

Ethyl Corporation C-4, C-5

— F —

Fluorline Co. D-82
The Foxboro Company D-6, D-7
Franks Division of Cabot Shops, Inc. B-14, B-15

— G —

Garrett Oil Tools, Division of U. S. Industries, Inc. B-77
Gar Wood Industries D-16
Gaso Pump & Burner Mfg. Co. D-2
General American Transportation Corporation, Plate & Welding Division A-20
General Electric Company, X-Ray Department C-62
General Hermetic Sealing Corp. E-18
The Goldak Company, Inc. D-66
W. R. Grace & Co., Davison Chemical Division C-69
Greenlee Tool Co. C-70
The Gulberson Corporation B-7

— H —

Halliburton Oil Well Cementing Company ..... B-50, B-69, B-79, Back Cover
The Happy Company B-143
Harbison-Fischer Mfg. Co. B-99
Hardy-Griffin Engineering Corporation, a Division of Atlas Pipe, Inc. B-122
Hercules Powder Company C-66
Hercules Tool Company B-136
H & L Tooth Company A-36d
H & M Pipe Beveling Machine Co. D-65
Houdry Process Corporation C-67
Houston Contracting Company D-18
Hughes Tool Company B-108, B-109
Hydril Company B-35, D-35

— I —

Ingersoll-Rand C-34, E-22
Insley Manufacturing Corporation D-3
Instruments, Inc. D-74
International Steel Company, Lindsay Structure Division E-18

— J —

Jensen Bros. Mfg. Co. B-137
Johns-Manville Products D-10, D-11
Johnston Testers, Inc. B-65
Jones & Laughlin Supply Division B-70, B-71

— K —

Klampon Corporation B-140
KLM Royal Dutch Airlines E-7
Koppers Company, Inc., Tar Products Division D-17
Kraloy Plastic Pipe Co., Inc. B-141

— L —

Lamar Hotel E-20
Lane-Wells Company ..... Inside Back Cover
Liberty Manufacturing Company of Texas B-107
Lone Star Steel Company A-7
J. E. Lonergan Co. E-16
Lufkin Foundry & Machine Company B-5

— M —

Mack Trucks, Inc. B-17
Maeder-Sevier Company D-63
Magnet Cove Barium Corporation B-101
Manzel, A Unit of Houdaille Industries, Inc. E-19
Marsh Instrument Company, a Division of Colorado Oil and Gas Corporation A-13
John N. Martin, Manufacturer B-120
Martin-Decker Corporation B-55
Mayer-Kelly Company D-76
Mercantile National Bank E-20
Merla Tool Corporation B-112
Mid-Continent Supply Co. B-91
Midwestern Pipe Line Products Company D-81
Miller Sand Pump Co. B-144
Milwhite Mud Sales Company B-129
Mission Manufacturing Co. B-52
Montello, Inc. B-126
Motorola Communications & Electronics, Inc. D-12
Frank W. Murphy, Manufacturer, Inc. D-76
M & V Tank Company B-144

— Mc —

McCord Corporation D-72
McCullough Tool Company B-4

— N —

The National Supply Company B-73, B-74, B-75, B-76
National Tank Company E-26
Naylor Pipe Company E-12
Nicolet Industries, Inc. A-36f
Nordberg Mfg. Co. D-13
Nordstrom Valve Division, Rockwell Manufacturing Company A-14, A-15
W. C. Norris, Manufacturer, Division of Dover Corporation B-89, B-106, B-143

— O —

Oakite Products, Inc. B-140, C-32, C-33, D-80
Oil Center Tool Co. B-119
Oil States Rubber Co. B-127
Oil Well Supply Division of United States Steel A-9, B-37
Orbit Valve Company B-130
Otis Engineering Corporation B-46, B-47, B-96

— P —

Parkersburg Rig & Reel Co. B-131
Parsons Company, a Division of Keehring Co. D-53
Permian Basin Oil Show B-127
Petreco, a Division of Petrolite Corporation A-36h
Petroleum Electric Power Association A-5
Pipe Linings, Division of American Pipe and Construction Co. D-77
Pipeline Cleaners Co. ..... D 64
Pipeline Inspection Co., Inc. D-64
Pittsburgh Coke and Chemical Company B-82, B-83
Polyken Products, Division of The Kendall Co. D-49
The Wm. Powell Company A-36e
Procon Incorporated C-29

— R —

Radiator Specialty Co. C-66
Radio Corporation of America, Electronic Data Processing Division E-24, E-25
Raybestos-Manhattan, Inc., Manhattan Rubber Division C-68
The Rector Well Equipment Company B-16
Reed Roller Bit Company B-86, B-87
Rockford Clutch Division, Borg-Warner B-121
Rockwell Manufacturing Co. B-124
John A. Roebling's Sons Division, The Colorado Fuel and Iron Corporation A-16
Rust-Oleum Corporation E-17

— S —

Salt Water Control, Inc. B-88
Schlumberger Well Surveying Corporation B-97
The Sealube Company E-20
Security Engineering Division B-11
Shaffer Tool Works B-58
Shell Oil Company E-5
Sievers, Inc. B-137
M. B. Skinner Co. C-63, D-80
A. O. Smith Corporation, Smith-Erie Division D-14, D-15
Tyson Smith Co. B-85
Smith Tool Co. B-144
Southern Pipe Division of U. S. Industries, Inc. D-78, D-79
Spang & Company B-117
Standard Oil Company (N. J.) E-21
Standard Pipeprotection D-67
The Stearns-Roger Mfg. Co. C-60
Steel Forgings, Inc. D-66
Stephens Engineering B-144
Sun Ship Building & Dry Dock Co. C-1

— T —

The Tapecoat Company D-41
Teletype Corporation, Subsidiary of Western Electric Company, Inc. D-1
Transcontinental Gas Pipeline Corporation E-15
Tretolite Division of Petrolite Corporation B-118

— U —

Union Wire Rope Corporation, Subsidiary of Armco Steel Corporation B-66, B-67
Unit Crane & Shovel Corp. B-1
United States Steel Stainless Steel B-125, C-30, C-31
Universal Atlas Cement Company B-98
Universal Oil Products C-61, D-73

— V —

Visco Products Company, Inc. B-56
Henry Vogt Machine Co. C-56

— W —

Warner-Lewis Company C-57
Washington Iron Works, Inc. C-64
Waukesha Motor Company B-123
Weiss, Inc. B-2
The Western Company B-114
Western Gear Corporation, Industrial Products Division D-43
Wheeling Machine Products Company E-19
The Wheland Company B-9
Wilkinson Products Company D-82
Williams Brothers E-20
T. D. Williamson, Inc. D-9
Wilson Manufacturing Co., Inc. B-134, B-135
Wilson Supply Company B-111
Wisconsin Motor Corporation B-60
W-K-M Division of ACF Industries, Incorporated A-36a, B-6, C-2

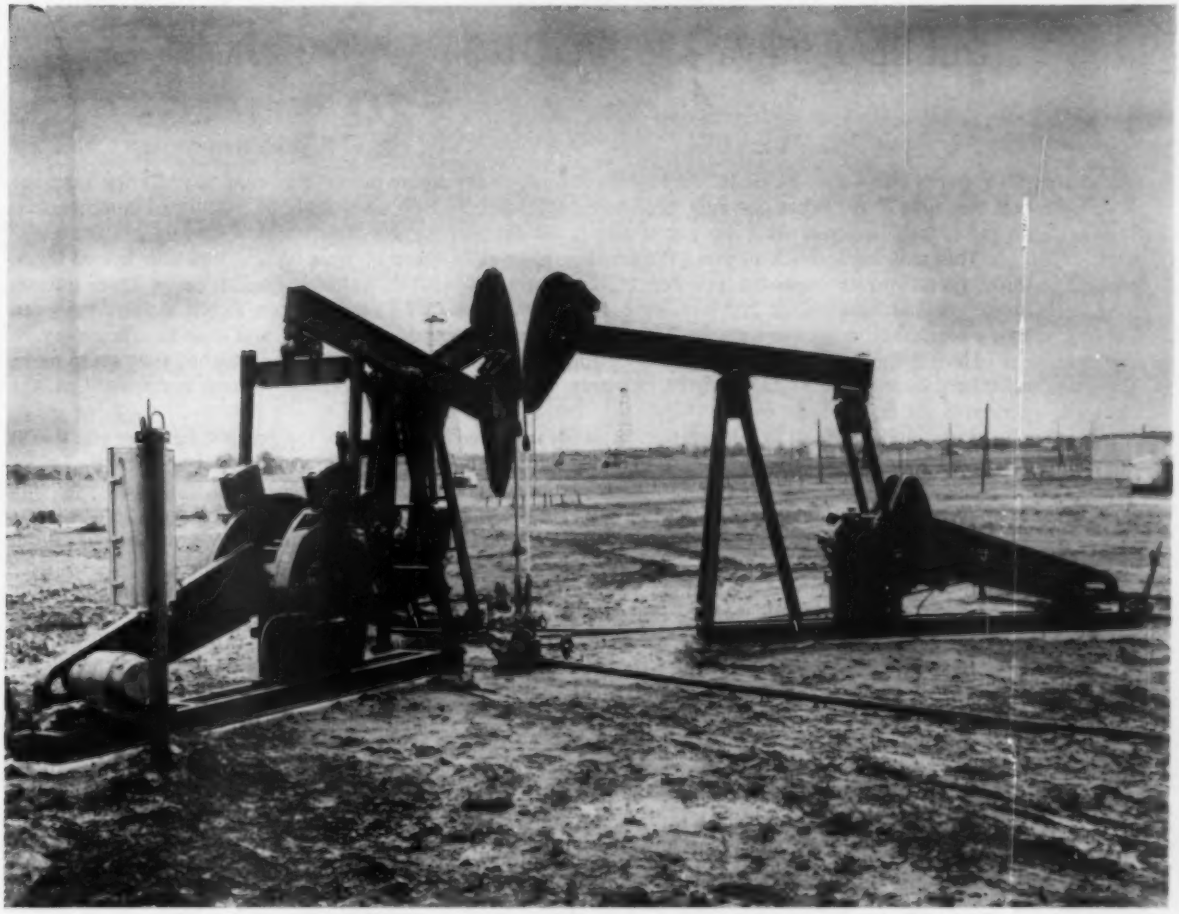
— Y —

Yuba Consolidated Industries, Inc., Adsco Division C-24

THIS INDEX IS PROVIDED AS AN ADDITIONAL SERVICE FOR OUR READERS — THE PUBLISHER ASSUMES NO RESPONSIBILITY FOR ERRORS OR OMISSIONS

You can depend on purchased electric power for

LOW COST PRODUCTION



Three zones being pumped simultaneously from single well with this utility-electric powered triple pumper

Economies of purchased electric power have been proven time and again for producers who have learned to depend on utility service in their fields. Saving in manpower and adaptability for automatic control makes utility electric power ideal not only for production but for gathering, pipeline and refinery operation. See your nearest utility electric power company for details or write the Petroleum Electric Power Association.

Purchased Electric Power . . . saves money; manpower; maintenance; and serves you better automatically

Petroleum Electric Power Association P. O. BOX 35006, DALLAS 35, TEXAS

Public Affairs are YOURS

ANY MENTION OF PUBLIC AFFAIRS sounds pretty anonymous. You may say, "They rang the bell that time," or "What got into those blooming idiots?" You are simply an intelligent commentator on the scene. The ones who run public affairs are those other people.

This may be a shock to you: Public affairs are right there in your hands. You can ignore them, throw them into an eager leader's begging cup, or — hopeful thought — you can shape them into an image you can understand and live with. That's what the API Committee on Public Affairs has been trying to get across to a million and a half people in the petroleum industry and their families.

Here is the dangerous aspect of our public affairs — if you don't use your rights, they go to make all others stronger. It's like a murder mystery. As each heir to a fabulous fortune is disposed of, the survivors get richer.

True, public affairs in our republic are only inherited. But they are the greatest heritage you'll ever have or ever hope to have. They are the best fortune you can leave to your children.

These rights are demanding too. They can make you or break you. No timid souls can cope with them. They X-ray the stuff you are made of. How you handle them determines your portion in life— your children's education, your income, your taxes, the welfare of your community, your industry, your nation.

If you ever thought you could get away from the responsibility (often inconvenient) and your right (sometimes a nagging duty) you are listening to the voice of the sirens, you are courting oblivion to yours and all individual rights.

In the Soviet Union, of course, you wouldn't have any part of public affairs. Mr. Khrushchev has gathered the whole lot in his empire into his strong tight fist. He holds the strings of conquest that lead to the desiccated rights of millions of people. He pulls them at will.

And how healthy is that authority you hold? How can you develop and protect it? The first thing to do is learn the care and nurture of your inherited rights in public affairs. They strengthen with exercise. They are nourished by thoughtful study. It is disturbing that children grow into adults with little knowledge and less precise training on the value of their heritage in public affairs. Remember those innocuous civics classes that gave you an outline of government? Nobody told you: You make the community, you must keep the state, you are the only indispensable unit in any governing body in this free land. You feed it, strengthen it by your adherence or submission to its decisions. You can undermine it, too. And at times you have.

At least give your children a laboratory lesson. Take them to the precinct meeting. Help them to realize that here is a board of directors that selects the management of our local, state and federal governments. Will they see their ideals trampled? Will they be shocked at the persons who have collected the rights of the indifferent and use them callously to achieve their own aims?

That should concern you. That should inspire you to stand and reveal that you, too, are on the board. You'll be surprised at how your rights grow in the air of freedom, with the food of decision.

Turn to the Conference Table in this issue and look at the questionnaire that Texas Mid-Continent Oil and Gas Association gives everyone in its workshops to fill out. Can you answer these questions? If not you'd better learn the answers. They are basic information for a man of public affairs. Unless you want to give your very own valuable heritage to the man on your left who will trade on it for more power to tax you, to direct your energies, to decide your job, to educate your children, to limit their heritage — then you'd better wake up, *member of the board of directors of every body that governs you.*

If you don't the day will come when some one will say, "Take me to your leader," and you won't laugh. You'll take him.

Ernestine Adams

Congrats and $25 for this quip to CAROLYN KENEDY, Bells Wells Oil Company, Box 269, Miami, Oklahoma.

When it comes to shapeliness . . . Lone Star pipe proportions are right! All dimensions and qualities are strictly API specifications.

Lone Star Steel . . . America's most modern pipe plant . . . is Joe Roughneck's solid source of supply. Right here in the center of the oil country . . . quick availability of Lone Star pipe is a terrific convenience.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.

Lone Star STEEL COMPANY

© 1956 Lone Star Steel Company

EXECUTIVE—SALES OFFICES
W. Mockingbird Lane at Roper • P. O. Box 12226 • Dallas, Texas
DISTRICT SALES OFFICES
912 Republic National Bank Building, Dallas, Texas
Houston, Texas | Midland, Texas | Tulsa, Oklahoma

PETROLEUM PROFILE

RALPH A. JOHNSTON
Chairman of the Board
Texas National Petroleum Company

TO HEAR Ralph A. Johnston tell it, he's had a very easy time. More accurately, he's been too busy to let rough spots deter him in the least.

"I didn't know a depression was on," he said of 1930. He found out when he was producing some East Texas properties in 1932 and oil dropped to 10 cents a barrel. Offset owners were selling thousands of barrels. His older brother, Bill, was on a committee to get up a petition to Governor Sterling to declare martial law. In 36 hours they got 10,000 names, hauling people out of bed to sign.

The trouble with Ralph is that he meets challenges so headlong that they somehow lose their stature.

He was born down in Albertville, Alabama, and was 10 years old when his father bought a farm near Okemah, Oklahoma. He decided early to be a geologist.

What gave him that idea? "We had an oil play around Okemah and I saw those scouts in leather puttees driving around in slick cars and spending money and I decided that's what I wanted to be," he explains.

His father sent him to Oklahoma University and you can somehow picture the parting because Ralph has hanging in his office a special print of Rockwell's SEP cover of the farmer father and his college-bound son sitting on a running board of a car waiting for the train to come in.

After four years at Oklahoma University studying geology, young energetic Ralph got his first job in 1923 as a geology scout for Empire Gas and Fuel (Cities Service) at Holdenville. In 1925 he decided he'd go back and get his master's, but he couldn't stand studying when there was all that oil business going on. After one semester, off he went to work again. Ralph established Texas headquarters for Sinclair in 1926. Later he was called to the Tulsa office.

In those days landmen could go in on royalty deals of their own and the dynamo from Okemah was busy even for him. Then, as he says, "Uncle Harry said no more of these deals on the outside for Sinclair men. I had to quit."

He sailed through the first years of the depression — first in Tulsa, then in Tyler, Texas, where he had (and still has) producing properties and ran into 10-cent oil. This may have made him wiser but it didn't slow him down. "Took a tour into Mississippi," he recalls, "and drilled four dry holes."

Even that spurred him on. He drilled around Houston, and other Texas areas, in Louisiana and Oklahoma. The first good strike he made was a thriller. "I wanted to go swim in it," he says.

Probably the biggest single discovery was on a lease in Scurry County, Texas, now the Kelly-Snyder field. In 1946 he bought the wildcat lease from a broker friend who just wandered in the office. A well was to be drilled in the area. The well turned out to be a dry hole. "The only reason I kept the lease was that the rental was only 50 cents an acre," Mr. Johnston admits. "If it had been $1, I'd have let it go." When Standard Oil of Texas made its initial discovery, Ralph and his brother, Bill, were beseiged with offers to purchase or farmout the lease, but they decided to "ride it down."

Biggest triumph came when Mr. Johnston went into the San Juan Basin, New Mexico, in 1947. Outside of a small gas field there were two wells when he began buying leases. These holdings eventually became the foundation of a promising new company, Johnston Oil and Gas, which in 1953 was formed with Johnston's Rocky Mountain properties. In 1955 this company merged with Texam Oil, which had interests in Texas only and became Texas National. Ralph Johnston became chairman of the board and W. Stewart Boyle, who was Texam's chief officer, became president.

Texas National Petroleum recently paid $19,200,000 for Utah Southern Oil Company's properties to extend the company holdings into Colorado, Wyoming, and Montana.

Ralph A. Johnston is now the top executive in a substantial and growing company and he fills the job as if he'd had all the management development courses in the world and passed all with flying colors. He delegates responsibility and has surrounded himself with men who swing into action with confidence in him and in what they are doing.

This is a beehive of activity — this Texas National headquarters in Houston. Mr. Johnston is also chairman of the board of South Coast Life Insurance Company, which he helped organize. It owns the building where Texas National has its offices. He has several commercial ranches and that brings civic duties, like president (1951-54) and chairman of the board (1954-57) of Houston Fat Stock Show and Rodeo. He is now on the executive committee and a director.

When he was urged to be Texas chairman of the National Cowboy Hall of Fame, he protested, "My secretary is president of the Desk and Derrick, an international oil women's organization, this year (that's Gladys Watford) and I don't think we can take on any more." Well, you know the old adage — the busiest man is the one to do a job. So you know who is on the Cowboy Hall of Fame committee.

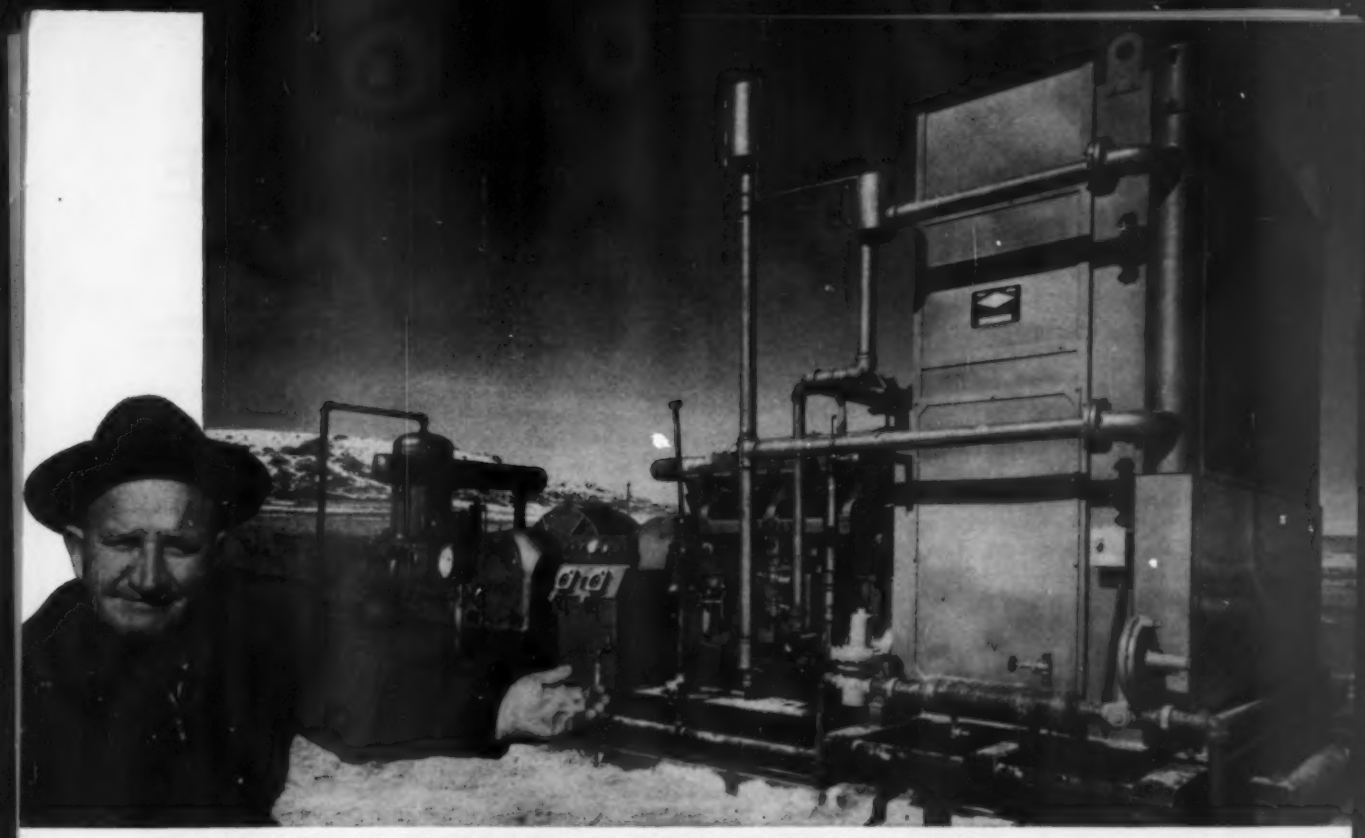
He likes to hunt, especially wing shooting, and some of his hunting companions give you an idea of the breadth of his personality — J. Frank Dobie, the Texas historian, is one, and Bernard Baruch, the national sage, is another.

Mr. and Mrs. Johnston (they were married in 1927 when he was in Abilene) have two children. The daughter, married to Richard Neal Andrew, lives in San Antonio. Son Jimmy, recently married, is at Texas University studying geology.

Mr. Johnston said he once talked of retiring, "But here I am at 60 working harder than I did at 40 and I've given up retiring."

If you ever met Ralph Johnston, you'd believe that — medium height, chunky, energetic, witty, and going strong.

He's much younger than his years. He doesn't even need spectacles yet!



Mr. G. H. "Ike" Fletcher, Production Superintendent for Belco Petroleum Corporation, shows the DGE-250, the largest on the job.

Pumping gas in Wyoming with "Oilwell" Compressors

At Big Piney, Wyoming, Belco Petroleum Corporation has five "Oilwell" Compressors pumping gas from twenty-seven wells to a main compressor station twenty miles away. At 7,400 feet above sea level, these installations are unprotected and the units operate continuously with minimum supervision. During winter months, when these pictures were taken, they are subjected to temperatures 30° or more below zero and are pelted by snow, hail and high winds.

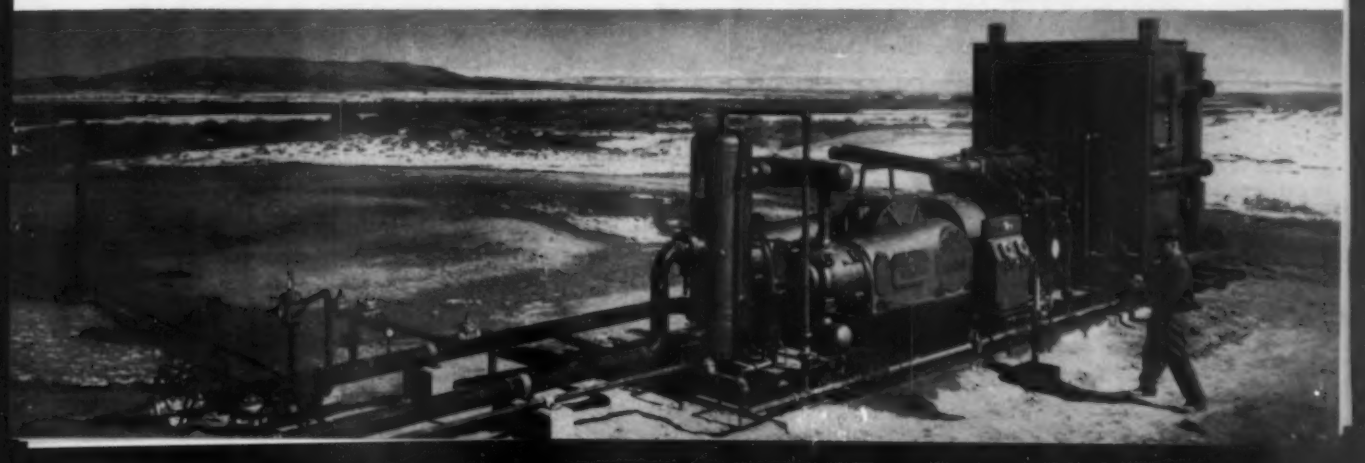
"Oilwell" Gas Compressors are designed in sizes from 25 to 300 hp and can be furnished to perform a wide range of gas-handling functions at high altitudes or at sea level. The excellence of their engineering and the high quality of their various components assure you of dependable performance—even under adverse weather conditions.

For natural gas pumping operations, contact your "Oilwell" representative for information as well as technical advice and assistance, or write Compressor Department, Oil Well Supply, Dallas 21, Texas.

USS and "Oilwell" are registered trademarks

Oil Well Supply Division of United States Steel

Executive Offices—Dallas, Texas
Export Office—30 Rockefeller Plaza, New York 20, N. Y



THE CONFERENCE TABLE

"Don't look back, somebody may be gaining on you"... SATCHEL PAIGE

How Much Do You Make?

"This week you paid $10 to the federal government. Do you know how it has been spent? Have you heard of any waste?" This notice, with the amount varying with the individual, is printed on the pay checks of a Kalamazoo, Mich., plant, explains the Terre Haute (Indiana) Tribune.

The practice arose when an employee gave notice that she was leaving her $69-a-week job for one elsewhere that would pay her $75. Actually she was getting not $69 but $80, the difference going to Uncle Sam. This misunderstanding, when investigated, proved quite common. Hence the notices on the pay checks.

People cannot be paid merely for living. It must be for earning a living.

Human Resources Come First

Americans have demonstrated that they have the best technical and material resources in the world, but their future will probably depend on the development of human resources and their ability to manage them, George F. Getty II, Tidewater Oil Company president, told a University of Houston audience when he received the student body's "Management-Man-of-the-Year" award.

Said Getty "Managers of the future must think of management in terms of leadership, and must learn to manage different ideas and different peoples with equanimity and confidence."

Americans have great resources to work with, in terms of education, experience and technology, Getty continued, and pointed out there has not been time to develop these resources in the new and struggling nations of Africa and Asia. This situation will place a heavy burden on the people selected as managers in these countries, but it will place an equally heavy load on Americans, Getty said.

Half of knowing what you want is knowing what you must give up before you get it.

Morals Morass of Bureaucracy

We're ruled and regulated, expanded and squeezed, controlled and reprimanded by the biggest flock of government bureaus this side of the USSR.

If you're on the outs with an agency that handles your business, brother, you'd better watch your step. Last time we counted, the oil and gas industry had close to a hundred bureaus to account to, not including those that cover all business — like the income and social security collection agencies.

On the whole they are made up of honest people who deal in the "power that corrupts" as fairly as human beings can. We've had a number of gifts revealed — mink coats, (wasn't Sherman Adams' vicuna?) refrigerators, pleasure trips, etc., that made good TV comedy lines. All you got back were laughs, of course. Hardly anybody understood that they had to be paid for somehow with tax money.

This concentration of power in appointed (never elected) members of a government bureau is the strongest argument against big government. Even more atrophying than the high and wasteful cost.

Recently three members of the Federal Power Commission have been called before a congressional committee because they *talked to an applicant* outside of a hearing. We'd say the FPC is made up of men of integrity. They are compelled by directives to be judge and advocate among other technical duties. The Congressman who questioned one appeared to believe he had fraternized with the enemy. The enemy was a mere applicant.

Now a judge can call the defendant or complainant and their lawyers into his chambers to get information — even in a criminal case — without disrupting the case before him. Here we have an inquiry from the august Congress because an applicant before the bureau was met outside the hearing room.

This is the morals state we've gotten into with our bundlesome bureaucracy. Some politically conscious Congressmen are putting the pharisees into shadow. On the other hand, who isn't nervous about the power of business controls (and who knows more about them than the petroleum industry?) and the split-hair decisions that can throw a whole industry into the doldrums.

There are so many bureaus now that Congressmen can't possibly know who's spending what. They're confused and so — to state it mildly — are we.

Then there is the Department of Justice — made up of lawyers hungry for a case. Just because their case of conspiracy for price increase fell on its face in the last trial against 30 oil companies, and because other cases of the same caliber have collapsed in court, don't think they won't bring another one as soon as they dream it up. They've begun to play percentages now and percentages are with them. The total cost of the trials just since the "Mother Hubbard" case could easily scratch out a billion dollars paid for by every person in this nation — both as taxpayer and consumer of oil and gas products. But very few know that. They probably wouldn't believe it if you told them. Someone else paid the bill (people on Mars?).

Knock out a few bureaus and streamline others and you'll find fresh progress. Red tape costs will take a dive and the money will go to employment and materials. There should be some politicians who could implement that plan. Maybe you'll be able to vote for one.

Such a course would drag us out of the morals morass and set us on a clear highway built on stouter principles.

It's all right to speak straight from the shoulder, but be sure it originates a little higher up.

You Should Read . . .

"How a BIG LIE Campaign Is Menacing Our Oil Supplies" by Dean S. Chaapel in *Our Sun*, a publication of Sun Oil Company, should have an industry-wide reading. Reprints are available upon request to Sun Oil Company, 1600 Walnut Street, Philadelphia 3, Pennsylvania.

This forthright piece gives you an unvarnished review of propaganda you should know. Three cartoons taken from newspapers will give some of you a shock.

Good Wells Make Good News

A Report on Recent Treatments Using Abrasijet

May, 1960

Abrasijet* — a Dowell-developed abrasive jetting service — uses high velocity streams of sand-laden fluid to perforate casing or clean hole walls. Here are four recent examples of the kind of results many operators have experienced.

- **Harrison County, East Texas** (New Oil Well) Pay zone was the highly soluble Glen Rose. Since the water table was only six feet below the producing interval, operator was afraid to use conventional perforating. Abrasijet was used to perforate from 4492 to 4493 feet with a vertical cut and from 4494 to 4495 feet with a vertical cut. 5000 gallons of 5 per cent acid and 5000 pounds of sand were jetted. Following Abrasijet, well tested 192 bopd without further treatment. This is considerably better than the 125 bopd average test of wells in the area that have been perforated with explosives and then acidized.

- **Lea County, New Mexico** (New Oil Well) This well was to be completed in the Grayburg and San Andres between 4501 and 4734 feet. Abrasijet was used to perforate because fracturing pressures of 6000 to 8500 psi had been required after conventional perforating. 55 levels were jetted allowing about four minutes at each level. Total jetting time was 216 minutes. Well was successfully fractured at only 4900 psi. Production is top allowable.

- **Kingman County, Kansas** (New Oil Well) This well was to be completed in the Mississippi lime at 4428 and 4434 feet. Other nearby wells had very high gas/oil ratios and were completed as gas wells. The operator wanted to get a low gas/oil ratio so this well could be completed for oil. Abrasijet was used to perforate at 4428 and 4434 feet. No further treatment was necessary. On test, the well swabbed 22 boph. Gas lift equipment was installed and a good well with a low gas/oil ratio resulted.

- **Montgomery County, Southeast Texas** (Old Oil Well) This well had depleted a lower zone of the Conroe sand, so the operator set a five-inch liner in the seven-inch casing before re-completing. Abrasijet was selected to perforate because of the heavy steel and cement sheath. Two perforations were jetted at each foot from 5019 to 5023 feet. 7500 gallons of salt water and 7400 pounds sand were used for jetting. Well came in flowing 54.5 bopd through a 10/64-inch choke. Gas/oil ratio was 507/1.

Many times, Abrasijet is the most economical way to perforate if a well is to be stimulated by fracturing or acidizing. Often, it has proved to be the only way to complete a problem well successfully. For service or detailed information, dial Dowell. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela and Argentina. Dowell, Tulsa 1, Oklahoma.

*Dowell Service Mark

Services for the oil industry DOWELL
DIVISION OF THE DOW CHEMICAL COMPANY

What? Not an Economist?

Why some of us duller types do not become economists has been made abundantly clear to use by a practitioner in that mysterious field.

We refer to a bit of mumbo-jumbo that a professor of economics posing as an expert on the petroleum industry, came up with recently. His name is Alfred Kahn. He is a Cornell University economist. He was speaking on oil at the American Economic Association meeting in Washington.

Kahn said the oil industry was not competitive, and declared the price of oil is "artificially sustained by prorationing and import restrictions."

He also dusted off the number one grievance held against percentage depletion by the college fraternity of economists. Depletion, he says, "attracts capital uneconomically into gas as well as oil," and tends "to keep the price of gas as well as oil uneconomically low and to encourage its excessive utilization."

We assumed here that this "uneconomically low" price was the same one which in that other breath he had claimed was artificially "sustained" by prorationing and import restrictions. This seemed a mite illogical to us. So we consulted one of our favorite experts on economics. "To an economist," our friend assured us, "the two thoughts are not contradictory at all."

Lloyd N. Unsell in IPAA Monthly

Troubles

If you talk about your troubles
And tell them o'er and o'er
The world will think you like 'em.
And proceed to give you more.
—Pittsburgh Post.

Quickie Questionnaire

Here is a questionnaire taken from Texas Mid-Continent Oil and Gas Association Public Affairs Conference. These are all questions you should have a correct answer for. If you don't have, back up and learn the answers for 1960. You'll need them.

1. What county do you live in? .....County
2. Do you have a 1960 Poll Tax? (Check one) ..... Yes .....No. This could be "Are you registered"?
3. Write last name of U. S. Congressman from your home district:.....
4. Name three members of the House of Representatives in your State Legislature:
   1..... 2..... 3.....
5. Name the member of the Senate in the State Legislature from your district:.....
6. What is the total state and federal tax per gallon on gasoline you buy? .....
7. Does the oil and gas industry pay any special tax in your state as well as excise taxes? .....
8. Have you written a personal letter to a member of Congress in the last year on (1) fuels policy resolution? .....Yes .....No; (2) percentage depletion? .....Yes .....No; (3) gasoline taxation? .....Yes .....No; (4) natural gas regulation? .....Yes .....No; (5) labor legislation? .....Yes .....No; (6) any other subject? .....Yes .....No
9. Have you written a personal letter to a member of the State Legislature about an oil or gas industry issue in the last year? .....Yes .....No
10. Do you belong to a civic or service club (such as Lions, Rotary, etc.)? .....Yes .....No
11. In Presidential elections, do you generally regard yourself as .....Democrat, ...Republican, or .....Independent? (Check one)
12. Have you ever made a personal contribution of funds to a political party or a candidate for public office? .....Yes .....No
13. Have you ever worked as a campaign volunteer for any political party or candidate? .....Yes .....No
14. What kind of job do you feel your employer does in keeping you informed on oil and gas industry issues? .....Good .....Poor .....Fair (Check one)
15. What attitude do you think the following persons have toward the oil and gas industry? (Check one)

	Friendly	Unfriendly	Don't Know
Chet Huntley	.....	.....	.....
William Proxmire	.....	.....	.....
Lyndon Johnson	.....	.....	.....
Dwight Eisenhower	.....	.....	.....
David Brinkley	.....	.....	.....
Jerome K. Kuykendall	.....	.....	.....
Frank M. Porter	.....	.....	.....
Paul Douglas	.....	.....	.....
Drew Pearson	.....	.....	.....
Matthew V. Carson, Jr.	.....	.....	.....
Richard Nixon	.....	.....	.....
Douglas Edwards	.....	.....	.....
M. J. Rathbone	.....	.....	.....
Oren Harris	.....	.....	.....

16. Have you made a speech before any sort of public gathering concerning the oil and gas industry in the last two years? .....Yes .....No. Do you recall reading or hearing about anyone in your company making a speech on an oil and gas industry subject during the past year? .....Yes .....No. If "Yes," who was the speaker? .....

Good Citizenship Prizes

Standard Oil Company (Indiana) had a contest on elections for children of company employees and annuitants (outside of top brass and public relations staff). For a Good Citizenship slogan on why it is important to vote in primary elections, 11 prizes were given. The contestant had to explain in 200 words why one should vote in primary elections, then write a 15-word slogan on the subject.

First prize is an expense-paid trip for winner and parents to Washington, D. C., for the presidential inauguration on January 20, 1961. Other prizes were U. S. savings bonds.

This is our idea of a worthy contest and we hope others can adopt it. It should intensify interest in better government.

Know it by the yellow handle

Use it because it embodies features never before combined in a needle throttling valve...

It is the first throttling and shut off valve that serves the whole range of pressures—from low to 10,000 psi—with equal efficiency all the way through.

It is the valve in which body and stem guide are one piece—completely fused into an integral leak-proof unit by the exclusive Marsh "Conoweld" process.

It is the valve in which the stem is precision machined and ground. Perfect stem alignment and fine threads provide easy and precise throttling. Special "Marpak" packing always holds tight; never binds.

Bodies of the 1900 series identified by the yellow handle are machined from high grade carbon steel bar stock marked in accordance with M.S.S. regulations showing size, material and service. Stems are 416 stainless steel. Valves are available in the patterns shown below; sizes ⅛", ¼", ⅜", ½", ¾" and 1".

Marsh Needle Valves are also available in 416 stainless steel throughout (identified by green handles). *Write for bulletins.*

MARSH INSTRUMENT COMPANY, Dept. M, Skokie, Ill.
Division of Colorado Oil and Gas Corporation

Marsh Instrument & Valve Co. (Canada) Ltd.,
9407 103rd St., Edmonton, Alberta
Houston Branch Plant, 1121 Rothwell St.,
Sect. 15, Houston, Texas

In stock at your nearest Supply House

MARSH

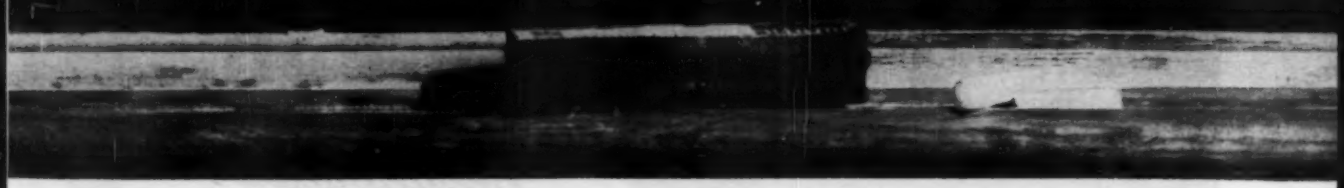
SERIES 1900

Needle Valves

Conventional Construction | **Marsh Construction**

In conventional valve (left) stem-guide is threaded into body... can be backed out when valve is fully opened, causing real trouble when pressure is high. Can't happen with Marsh design (right). Marsh stem-guide is welded to body.

On most this valve never needs



There are a few valve-killing services where Rockwell-Nordstrom valves *do* fail—after outlasting non-lubricated valves by ten or twenty times. But on *most* services—when properly specified and properly maintained—they last as long as the installation of which they're a part. This is why: Rockwell-Nordstrom valves are *lubricated*. Pressurized lubricant in the Sealdport system does three things. 1) It creates a powerful leak-proof seal that can't be permanently damaged because it *renews itself*. 2) By hydraulically cushioning the plug, lubricant *prevents freezing and jamming*. 3) Lubricant protects every moving part against wearing *friction* and no vital part is exposed to the line. The lubri-

Lubrication makes the

cation largely eliminates the *causes* of valve failure. How much would you save if you had a valve that never needed to be replaced—or that outlasted your present valves by ten or twenty times? Try just *one* Rockwell-Nordstrom Valve on your toughest service. *Rockwell Manufacturing Co., Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Ltd.*

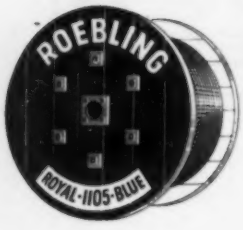
ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

difference . . . . . .

IF THE WIRE ROPE YOU'RE USING HASN'T GOT IT HERE...IT HASN'T GOT IT

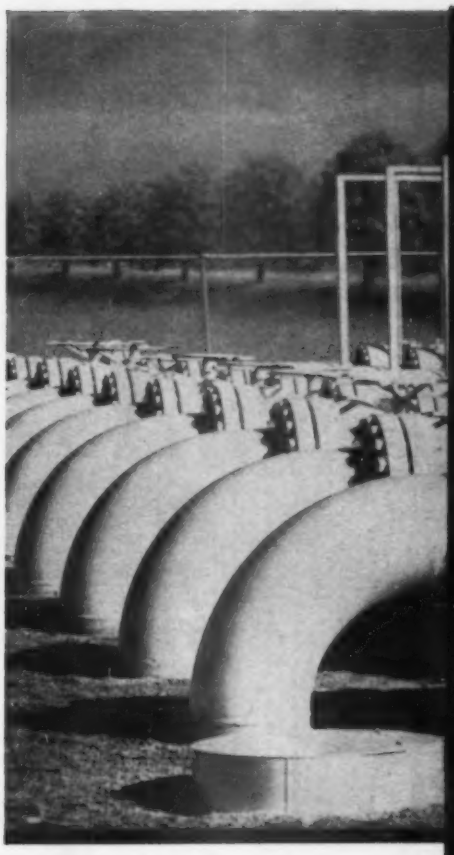


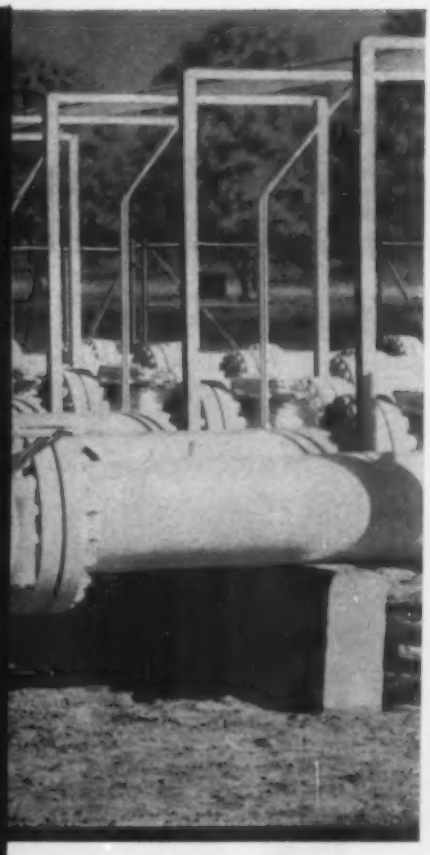
This rope has it—and has it at every critical point of wear for these reasons:
Extra Resistance to Bending Fatigue · Extra High Strength
Good Flexibility and Excellent Resistance to · Shock · Abrasion · Impact · Crushing
For anything you want to know about Roebling Royal Blue Wire Rope, ask your Distributor or Roebling's Wire Rope Division, Trenton 2, N. J.

ROEBLING

Branch Offices in Principal Cities *John A. Roebling's Sons Division* · *The Colorado Fuel and Iron Corporation*

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



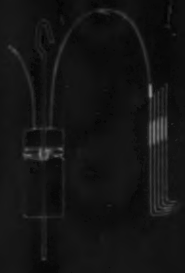


ORIFICE METERS

American-Westcott Dri-flo and mercury manometers in recording, indicating and integrating models—to 5000 psi working pressure.

GASCLOK

Gas or air-operated instrument power drive and timing unit for remote installations.



CANNON PENS

Controlled flow capillary meter pens record up to a full year without refilling—eliminate chart smearing and blurring.

CONTROLLERS

Series A-88 Controllers, Transmitters & Receivers for control of continuous process variables. Telemetering Systems designed to meet your requirements.

RELY ON AMERICAN® INSTRUMENTS FOR YOUR TOUGHEST JOBS

American's complete line of equipment sets the highest standards for accuracy and dependability. Ask your American representative about their applications and advantages for your measurement and control problems.

AMERICAN®
METER COMPANY
INCORPORATED ESTABLISHED 1836

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany Atlanta • Baltimore • Birmingham • Boston • Chicago Dallas • Denver • Houston • Kansas City • Los Angeles Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood

IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario Calgary • Edmonton • Montreal • Regina • Vancouver

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

How our small plant solved its waste disposal problem WITHOUT CAPITAL OUTLAY....

Pat. No. 2,900,096

DEMPSTER-DUMPMASTER Equipped Hauler Provides Containers and Service for Small Fee

Our small Midwestern manufacturing firm did not generate enough refuse to justify ownership of its own refuse disposal system. Yet, it was plagued by unsightly trash piles, fire hazards and scattered refuse in the plant yard.

Our plant engineer then heard of a DEMPSTER-DUMPMASTER equipped private hauler in the adjoining city. A survey revealed that two big-capacity refuse containers, placed one at each end of the plant, would handle the entire refuse accumulation.

The private hauler placed the containers, and a small monthly fee covered maintenance, labor, hauling and dumping refuse. No capital outlay was involved, disposal costs were reduced, and plant housekeeping was vastly improved.

In all major cities, private haulers who own DEMPSTER-DUMPMASTER equipment render fast, efficient, low-cost refuse storage and collection service. They place one or 100 containers at your service for a reasonable fee. A free brochure describes their service in detail.

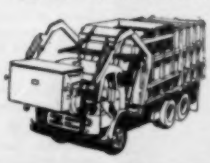
Free Brochure and Name of Nearest Private Hauler on Request

Dept. PE-5 DEMPSTER BROTHERS Knoxville 17, Tenn. Inc.

IN ALL LEADING CITIES FROM COAST TO COAST

DEMPSTER-DUMPSTER

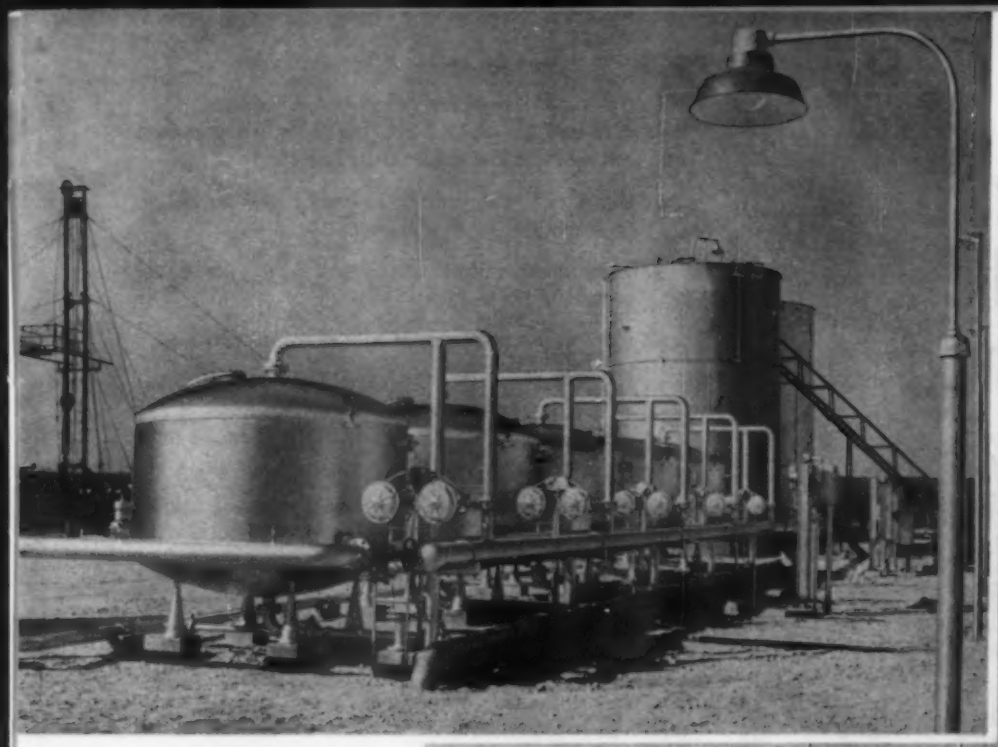
DEMPSTER-DUMPMASTER

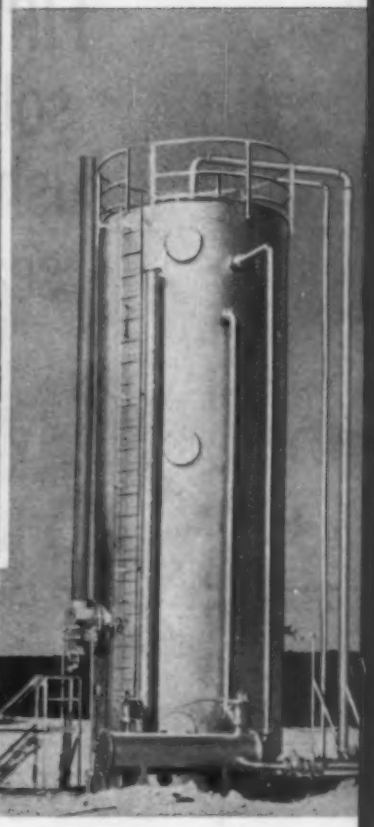


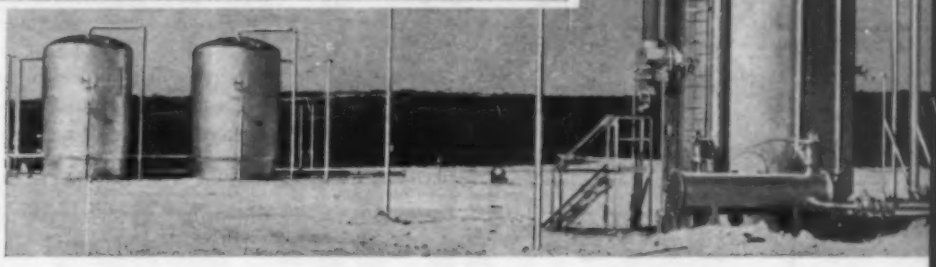
DEMPSTER COMPACTION TRAILER

DEMPSTER DUMPMASTER®

EQUIPPED PRIVATE HAULERS







Automatic Waterflood System . . .

Utilizes BS&B AQUA-Kleener!® Filters, Oilfield Equipment and Controls

Down in Mid-Texas, there's a "young" waterflood just getting well started that operates on a completely *automatic* basis — with the aid of 5 BS&B AQUA-KLEENER Filters, 2 BS&B Free Water Knockouts, a BS&B Type S Treater, several BS&B Bolted Steel Tanks and numerous BS&B Controls. These include valve actuators, time clock controls, liquid level controls and pressure differential controls.

In this system, production water from the treater and the free water knockouts is combined with "source water" from 2 750-bbl. tanks (fed by 2 water wells), and is pumped through the filters to the injection pumps, and thence into several injection wells.

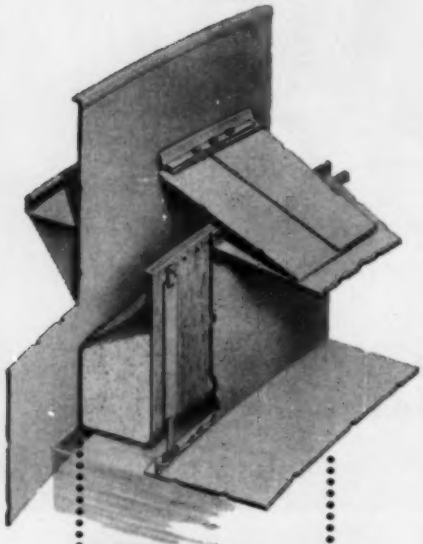
The 5 filters are controlled by a preset time clock on a cycle that keeps some of them on stream while others are on automatic backwash. The piping manifold on the filters and twin valves is so arranged that when the time clock closes the inlet valve, it opens the other valve starting the backwash cycle.

This installation is a good example of BS&B "Oilfield Automation" at work. Why not let your BS&B Man help you put your operations on an automated basis, too?

BS&B — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC., DEPT. I-C5 P. O. BOX 1714, OKLAHOMA CITY

FIRST solid cushion seal



When General American developed EverSeal, first solid cushion seal for floating roofs, we wanted a seal that would have these advantages:

1. Simplicity of design, no moving parts, nothing to corrode
2. Permanent, indestructible sealing qualities—no gas or liquid to leak
3. Complete protection of coated tank walls from scuffing or gouging
4. A tough, pliable envelope that would withstand abrasion; ride without damage over projections on the shell
5. Ease of repair or replacement, without taking tank out of service
6. Maximum protection against evaporation loss
7. Full protection of oxygen-sensitive stocks
8. No build-up of vapors in the seal area

EverSeal is the *first* solid cushion seal to meet *all* these requirements. It is made of trapezoidal urethane foam cushions enclosed in a tough, scuff-proof envelope of Buna "N" synthetic rubber and polyvinyl chloride plastic.

EverSeal is almost impossible to damage, always provides a safe and complete seal for every floating roof.

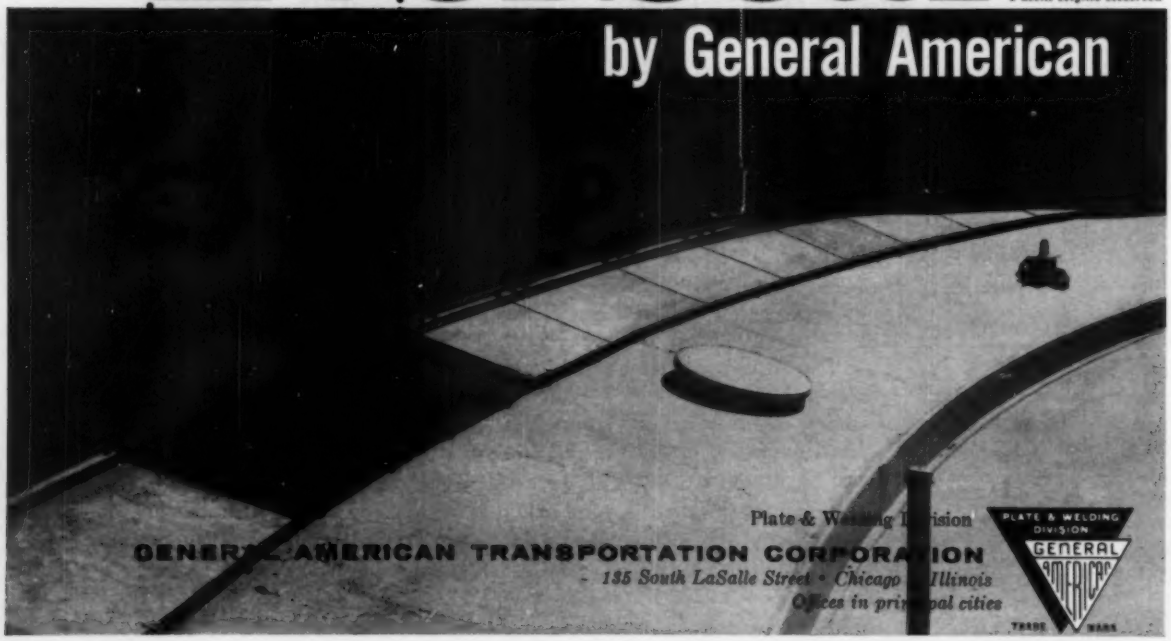
Write or phone your nearest General American office for complete information.

It pays to plan with General American.

EverSeal*

*Patent Rights Reserved

by General American



FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

WHERE DO WE GO FROM HERE?

To find the answers we sought the annual reports where management tells the company shareholders what has been done and what is coming. The 1959 reports of 75 corporations reveal we are headed toward...

→ Expanded Research

→ Increased Petrochemicals

→ Rise in Natural Gas Role

→ Rise in Foreign Investment

→ More Balanced Operations

→ Greater Diversification

ERNESTINE ADAMS
Management Editor

FINANCIAL

1959 Was Better Than You Think

How do 1959 petroleum industry earnings last year compare with 1958?

The 75 companies in our annual survey can give you the best answer to that. Their earnings struggled back with a 9.2% rise over 1958. In 1958 earnings were down 21 percent from the high of 1957 so we didn't catch up in one year but made some progress (See Table 1).

This is what CONTINENTAL OIL COMPANY says: "Last year the petroleum industry made a good recovery from the depressed conditions of the 1957-1958 recession. Despite the business slowdown resulting from the steel strike, domestic demand for petroleum products was about 3.6% higher than in 1958. This increase — the largest of the last three years — is once again in line with the anticipated long-term trend."

SKELLY OIL COMPANY wasn't so pleased: "Our fortieth year, which opened with such high promise, failed to meet early expectations, but did close with profits ahead of 1958. Gains of earlier quarters were reduced in the third and fourth quarters as production allowables were cut drastically, and the persistent oversupply of petroleum products led to disastrous price wars, and a general weakening of market prices."

And not every company enjoyed increased earnings. ARGO OIL CORPORATION explains: "The decline in net earnings was due principally to unusually high charges for abandonments, dry holes and well workovers. Charges for depreciation and depletion were substantially higher than in the preceding year."

Along the same line, DRILLING AND EXPLORATION informed its stockholders: "Net earnings would have shown a more substantial increase over those of the preceding year except for the incurrence of heavier exploratory costs and the imposition of foreign income taxes at an effective rate higher than in previous years."

This seems like good progress. Why do people say the industry is in the doldrums?

You have to get the background as STANDARD OIL COMPANY (INDIANA) paints it: ". . . 1959 brought to a close a decade in which overcapacity, a consequence of the postwar petroleum boom and of imports pressures, was strikingly characteristic of the oil industry. Twice during the fifties international events changed the oversupply picture (in 1950 the Korean war and in late 1956 Nasser's seizure of the Suez Canal). Accelerated activity in these two crises masked temporarily the true state of affairs. Fact was that throughout the decade the industry could — and too often did — produce more, import more, and refine more than real demand warranted. Profitability suffered most during the recessions of 1953-54 and 1957-58 but in other years as well."

This oversupply is a constant burden that only a remarkable industry could carry as well as it does. As KENDALL REFINING COMPANY checks it: "Improvement in general business which followed the 1958 recession brought with it an increased demand for petroleum products. The domestic oil industry responded with such increased production of crude oil and refined products that inventories rose to levels obviously excessive before midyear."

Comments the MIDWEST OIL CORPORATION: "Some of the economic difficulties that plagued the industry over the past two years have lessened, but they have not been eliminated. During this period the pressure of excessive inventories caused downward price adjustments. As a result, current crude prices are at a three-year low. All exploring and producing costs, however, have continued to rise."

SHELL OIL COMPANY saw carryover from 1958 as one cause of industry problems: "Demand for petroleum products in the United States during the year showed an increase of approximately 3.5%. However, the disappointing demand in 1958 left the industry with over-heavy inventories of products going into the new year so that, in spite of the improving demand, prices were generally weak and indeed, periodically broke to levels affording no profit at all in some parts of the country."

TXL OIL CORPORATION names two factors: "Presently there exists a worldwide excess capacity to produce and refine oil, which exerts a seriously depressing influence on the domestic petroleum industry. Two factors largely account for this situation: First, the Federal Government urged the domestic industry to build up a reserve capacity for purposes of national defense; second, there has been an intensive competitive drive by the international oil companies to maximize current lower cost production from foreign properties."

SUPERIOR OIL COMPANY was gloomy in spite of its report: "While revenues and earnings for the past year were the highest in the company's history, Superior's ability to meet the challenges facing the troubled oil industry continues to be severely tested."

Were sales of petroleum products up last year?

That is a little difficult to get from annual reports. Gross income — from sales and other revenues — went up 5.2% over 1958. This occurred in the face of declining prices of crude oil

and some products. At the same time natural gas prices and volume edged upward and petrochemical sales increased considerably. We must realize that within the range of the petroleum industry we have diversified branches.

Then earnings increased more than revenues?

That is one of the most promising factors in this survey of a fair-to-good year. Volume has been expanding in past years but profit margins have been nibbled down to anemic thinness. Percentages of earnings to revenues dropped even in the good year of 1957. For the last two years they have been:

1958, 7.7%.
1959, 8.0%.

This year's rise is barely perceptible but it does show a possibility the trend is halted if not reversed. The drop in 1958 was alarming.

For the first time in nine years instead of decreasing rate of return on net worth, an improvement was made. Below are the rates for 10 years:

1950	**15.5%**	**1955**	**13.0%**
1951	**16.8%**	**1956**	**12.7%**
1952	**14.6%**	**1957**	**11.8%**
1953	**14.5%**	**1958**	**9.0%**
1954	**13.0%**	**1959**	**9.3%**

Is everything up on the financial side?

Almost — revenues, earnings and net worth are the most important. Dividends are about the same. The one sharp drop is in price of common stocks. Virtually all of them are down.

On December 31, 1958 one share of common stock in each of 75 companies would have cost you $4615⅝. One year later, the same stocks could be bought for $3629¼. This is a 21% slide in one year.

On the '58 price, cash dividends alone amounted to a bare 1.7%. (Need of large capital investment in the petroleum industry, brings a lot of stock dividends in lieu of cash.) On the '59 price of $3629¼ for shares, cash dividends were 2.2%.

The petroleum industry has attained remarkable financial stability despite the play of many opposing forces. According to 1959 financial statements, our industry is headed in the right direction, even if the going is slow.

Throughout all the reports, there is stress on greater efficiency and savings gained by better organization and more modern equipment. SINCLAIR'S statement concerning improved operations indicates much of the reward is still to come.

"As the result of an intensive survey of all company operations, programs are now in effect by means of which substantial cuts in costs and expenses will be accomplished and efficiencies increased; however, the benefits of these programs will not be fully reflected until the second and third quarters of the year. Another factor favorable as to earnings will be the results flowing from capital expenditures made in the recent past, particularly in the petrochemical field."

Will companies be spending as much this year on capital expansion and exploratory projects?

It's surprising how much is budgeted for properties and equipment. And, in spite of the oversupply load, exploration is getting its usual big part of the planned expenditures.

Overall estimates of 1960 capital outlays by U. S. companies here and abroad show an increase of 5% above 1959. This is slightly higher than the 2% estimated in January for the Outlook in *The Petroleum Engineer*.

Based on figures from the companies who supplied breakdowns by operations and by area — our estimates are contained in the table on this page.

As we've often said capital outlays are a far from a precise term and are subject to drastic change. Since majority of funds are acquired from earnings, expenditures depend on profits that are accumulated during the year.

The predictions are based on 32 companies that made some separation of capital budgets by department and by area. Total expenditures are estimated from plans of 57 companies that provided 1960 figures for capital outlays.

Drilling and production include some exploratory expenditures, such as dry holes. As we have pointed out before there is considerable variation in what companies capitalize and what they consider expense items in this area.

Indications point to a 4% increase in domestic outlays — a 6% increase in foreign expenditures by U. S. industry.

We find drilling and producing with slightly less budgeted for 1960 than was spent last year. Foreign plans are barely more than the 1959 funds.

Our figures show a 34% increase in refining and petrochemical investment. The large market outlays are out of proportion with past figures but our data clearly show this upturn. Of course, a substantial portion is accounted for by purchases. Marketing facilities of a number of companies changed hands in 1959 and, evidently, are expected to in 1960. There is a determined drive, also, for modernization and a trend to huge super-stations.

It should be a good sign that estimates this April are higher than December estimates. Both in 1958 and 1959, capital budget figures took a slump between December (when the Outlook estimates were made) and April (when this annual report survey was done.)

The fact that there was a rise this year gives an impression that company managements feel they are on solid ground and have planned a course they are confident they can handle.

CAPITAL EXPENDITURES OF U.S. COMPANIES
(Millions)

	1959			1960		
	U.S.	Foreign	Total	U.S.	Foreign	Total
Drilling/ Production	$3,760	$1,200	$4,960	$3,715	$1,210	$4,915
Transportation (not gas transmission)	330	125	455	405	115	525
Manufacturing (including petrochemicals)	665	210	875	870	300	1,170
Marketing	610	190	800	695	215	915
Other	165	15	180	115	10	125
TOTAL	$5,530	$1,740	$7,270	$5,800	$1,850	$7,650

COMPLETES 90 YEARS

First oil company to finish 90 years of continuous operation is The Standard Oil Company (an Ohio Corporation). Sohio is a medium-size integrated company with net worth of $280 million.

TABLE 1. FINANCIAL STATISTICS OF U. S. PETROLEUM COMPANIES FOR 1959.

Company	Income—Add (000) Gross 1959	% [10]	Net 1959	% [10]	Taxes—Add (000) Direct 1958	Direct 1959	Excise 1959	Common stock 1000 shares	Per common share issued Price 12/31 1959 [11]	Equity 12/31 1959	Net income	Direct taxes	Dividends
Amerada Petroleum	$ 102,367	0.0	$ 24,023	+ 6.8	$ 7,557	—	—	$ 6,313	$ 76	$27.78	$3.81		$2.00
American Petrofina	76,848	+ 8.4	1,016	+706.3	1,418	1,536	15,230	6,977	7⅞	8.56	0.15	0.22	0.15
Ambassador	6,313	+ 72.8	802	+113.5	215	341	—	3,667	3¾	2.80	0.22	0.05	none
Anderson-Prichard	73,130	+ 5.2	6,885	+ 79.0	1,716	2,230		1,656	33¼	32.73	3.90	1.35	1.35
Argo Oil Corp.	14,497	+ 9.9	4,378	+ 11.0	1,296	897		2,000	29⅛	16.90	2.25	0.45	1.45
Ashland O. & R. [5]	300,644	+ 7.3	14,349	+ 38.9	8,050	12,830	48,101	6,102	23½	20.69	2.09	2.10	1.00s
Atlantic Ref.	542,131	— 0.5	30,174	— 16.5	16,992	20,899	91,454	9,051	41⅝	53.20	3.19	2.31	2.00
Aztec Oil & Gas	8,375	+ 93.4	5,138	+144.9	186	425		2,515	22½	6.93	2.04	0.17	5%s
Blackwell O. & G.	1,516	+ 2.1	263	+156.7	87	87		3,280	1½	1.11	0.08	0.03	0.03
British-American	330,943	+ 3.2	25,602	+ 24.8	19,169	21,072	60,853	20,459	34¾	20.39	1.25	1.03	1.00
Champlin O. & R.	84,620	+ 6.3	8,548	+ 17.0	3,379	3,538	8,972	4,129	20½	15.95	2.00	0.80	1.00
Cities Service	994,879	— 2.0	42,434	+ 10.7	26,178	23,853		10,729	48	60.79	3.95	2.22	2.40
Clark O. & R.	87,366	+ 15.9	2,127	+ 49.5	1,510	2,763		1,528	15¼	11.78	1.39	1.81	8%s
Coastal States	4,308	+ 40.4	1,586	+ 58.4	145	203		1,928	34	5.04	0.82	0.11	none
Colorado O. & G.	45,779	+ 37.4	2,527	+338.8	767	990	5,285	3,141	19⅜	8.04	0.63	0.32	none
Continental Oil	786,752	+ 14.6	60,272	+ 24.5	22,927	35,901	86,267	21,123	55¾	21.46	2.85	1.70	1.70
Cosden Petroleum	84,294	+ 5.5	5,129	+ 13.4	3,265	4,079	10,727	2,995	20⅝	14.33	1.91	1.36	1.00s
Crescent Petroleum	22,589	+ 37.3	2,596	+ 41.8				2,742	19	9.24	1.20		p.s.
Delhi-Taylor	86,578	+ 28.0	2,707		22,578	25,250		5,263	12⅛	3.94	0.51	0.22	none
Drlg. & Exploration	10,094	+ 2.4	760	+ 0.7	50	185		1,896	8⅞	8.98	0.40	0.06	0.25
Eason Oil Co. [4]	3,461	— 7.5	337	— 34.3	140	119		363	11	19.77	0.94	0.67	0.20
Fifteen Oil Co.	2,555	+ 0.4	480	+163.4	204	215		1,294	12	5.95	0.37	0.17	0.30
Frontier Refining	32,611	+ 11.5	762	— 1.9	306	603		1,152	11	7.63	0.64	0.20	0.25
General American	26,092	+ 4.6	5,653	— 29.2	1,611	1,507		3,348	25	23.77	1.69	0.45	0.40s
General Crude	13,461	+ 11.8	3,367	+ 17.7	1,162	1,339		1,941	26	13.40	1.73	0.69	1.00s
Getty Oil Co.	48,572	+ 9.6	10,661	— 17.2				16,004	18⅞	9.92	0.67		none
Gulf Oil Corp.	3,170,847	— 0.8	290,467	— 11.8	209,111	193,792	457,837	100,120	36¾	26.28	2.90	1.97	0.97
Helmerich & Payne [6]	14,241	+ 5.2	326	+173.3	75			1,892	7	4.67	0.17		5%s
Honolulu Oil	44,976	+ 10.3	12,894	+ 8.9	5,018	4,640		3,751	46⅞	24.51	3.44	1.19	2.00
Hugoton Production	7,542	+ 17.3	3,460	+ 29.8	1,815	2,072		851	79¼	13.48	4.07	2.44	3.00
Husky Oil [3]	29,993	+ 2.0	878	— 36.5	550	597		3,314	6¾	4.53	0.18	0.18	none
Intex Oil	2,455	— 16.2	447	— 41.9	167	154		793	7⅞	6.75	0.57	0.19	none
Kendall Ref. [7]	22,503	+ 12.4	989	+ 31.1	1,069	1,298		397	24⅛	35.76	2.49	3.27	1.25
Kerr-McGee [3]	134,165	+ 11.9	5,873	+ 9.2	1,457	2,970	28,794	2,396	50½	51.35	2.45	1.24	0.80
Leonard Refineries [3]	54,240	+ 2.0	1,339	— 9.8	2,069	1,901	6,140	1,120	14½	15.55	1.20	1.70	0.50
Louisiana Ld. & Exp.	38,667	+ 17.7	19,366	+ 11.5	10,479	13,091		8,973	51¼	4.40	2.16	1.46	1.60
Macmillan Pet.	15,249	— 1.4	232	+318.3	170	412	289	1,040		3.11	0.22	0.40	0.05
Midwest Oil	20,784	+ 6.8	7,368	+ 1.4	2,696	2,221		2,508	33½	16.25	2.94	0.89	1.81
Monterey Oil [5]	22,972	+ 5.0	2,459	— 0.8	1,200	1,350		1,877	23	29.45	1.31	0.72	s
Murphy Corp. [2]	45,494	+ 59.2	2,919	+ 5.8	1,448	1,217		2,449	22	17.08	1.19	0.50	none
Nortex O. & G.	2,048	+ 5.4	201	+267.4				695	4	2.98	0.12		none
Ocean Drlg. & Exp. [2]	6,428	— 16.4	(431)	—384.1	68	65		1,471	15	5.25	(0.29)	0.04	none
Ohio Oil Co.	349,472	+ 27.4	38,633	+ 20.1	12,830	12,426	44,774	13,974	38⅝	29.22	2.76	0.89	1.60
Phillips Petrol	1,179,247	+ 9.9	104,639	+ 24.2	45,546	83,531	130,000	34,358	47¼	30.64	3.05	2.43	1.70
Plymouth Oil	86,994	+ 4.3	2,186	— 52.4	680	1,100		2,652	22⅜	21.44	0.84	0.41	1.20s
Producing Properties	8,174	+ 90.3	669	+136.4	302	459		2,600	4⅜	2.38	0.20		none
Pure Oil Co.	621,437	+ 6.2	28,905	+ 0.3	8,035	10,905	116,547	8,700	37⅝	45.84	3.32	1.25	1.60
Quaker State	55,241	+ 10.6	2,383	+ 26.0	3,031	3,050		927	26¾	32.12	2.89	3.70	1.60
Republic Nat. Gas [3]	17,029	+ 4.2	4,069	+ 31.2				2,999	30⅜	12.52	1.36		0.60
Richfield Oil	269,932	+ 4.5	28,058	+ 39.6	14,756	20,633	72,148	4,039	77½	60.92	6.95	5.11	3.50
Shamrock O. & G. [9]	57,057	+ 1.0	9,182	+ 1.4	2,588	2,791	8,500	3,481	38	21.04	2.64	0.80	1.60
Shell Oil Co.	1,819,954	+ 8.7	147,418	+ 14.6	56,214	98,948	320,005	60,573	42½	21.88	2.43	1.63	1.02½
Signal Oil & Gas	194,245	+ 34.0	16,257	— 0.7	7,182	8,182	26,110	9,508	30½	20.00	1.17	0.86	0.80s
Sinclair Oil	1,246,363	+ 3.7	45,526	— 8.0	59,912	48,028	241,107	15,371	54½	63.03	2.96	3.12	3.00
Skelly Oil Co.	259,580	+ 1.5	27,992	+ 1.1	13,478	13,528	29,300	5,746	54	62.68	4.87	2.35	1.80
Socony Mobil	3,516,642	+ 7.9	163,952	+ 4.6	143,018	151,816	366,283	48,582	41½	51.87	3.38	3.12	2.00
South Penn	56,930	+ 5.0	3,340	+ 10.2	2,788	3,186	5,983	1,703	29	31.28	2.11	2.03	2.00
Standard Oil Calif.	1,909,064	+ 0.3	253,599	— 1.6	98,437	87,530	229,868	63,224	50¼	33.53	4.01	1.38	2.00
Standard Oil Ind.	1,980,779	+ 5.2	139,597	+ 18.5	61,822	81,003	390,935	35,770	44⅛	60.44	3.90	2.26	1.93
Standard Oil N. J.	8,714,000	+ 5.5	629,778	+ 12.1	805,700	846,000*	611,300	216,533	49⅜	30.89	2.96	3.91	2.25
Standard Oil Ohio	368,088	+ 2.8	25,061	+ 4.2	15,851	19,926	95,233	4,849	55¾	53.92	5.02	4.11	2.50
Sun Oil Co.	746,265	+ 3.1	42,844	+ 33.6	19,512	42,083	189,500	12,419	54	47.19	3.48	3.39	1.00s
Sunray Mid-Con.	450,989	+ 12.1	43,815	+ 7.7	20,663	23,435	44,447	17,918	23⅝	21.82	2.25	1.31	1.32
Superior Oil [5]	131,917	+ 18.4	19,356	+ 16.9	8,662	12,742		422	1321	371.54	45.84	3.02	4.00
Texaco Inc.	2,830,796	+ 9.7	354,346	+ 13.9	160,605	187,407	485,203	60,541	85⅝	41.59	5.85	3.10	2.60s
Texas Gulf Prod.	17,654	— 4.4	4,189	+ 5.4	2,273	2,633		4,035	33	14.69	1.04	0.65	0.60
Texas Pacific	26,149	+ 10.8	7,197	+ 15.5	1,856	2,038		3,883	25⅞	19.68	1.85	0.52	1.00
Three States Gas	5,146	+ 4.7	85	— 5.8	299	334		6,500	3⅝	0.81	0.13	none	none
Tidewater Oil	559,442	+ 1.2	33,941	+119.7	15,747	20,028	113,693	13,853	24	30.11	2.23	1.45	5%s
TXL Corp. [3]	13,040	+ 11.5	4,072	+ 8.7	915	1,320		5,574	18½	6.07	0.73	0.24	none
Union Oil Calif.	512,962	+ 4.2	27,515	+ 10.2	16,703	21,290	83,780	8,532	42¾	52.97	3.22	2.50	1.00s
Union O. & G. La.	45,211	+ 29.7	14,624	+ 79.6	1,939	3,269		4,741	41	11.59	3.08	0.69	0.40
Universal Consol.	8,092	— 5.6	3,059	+ 10.3	1,321	1,256		959	36¾	20.42	3.19	1.31	2.60
Wilcox Oil	6,418	— 16.2	983	+ 8.0	238	257	663	313	38½	34.00	3.14	0.82	1.00s
Woodley Petroleum	9,181	+ 19.5	3,765	+ 21.7	368	463		853	49½	25.45	4.42		0.50
TOTALS	$35,500,612	+ 5.2	$2,842,900	+ 9.2	$1,991,571	$2,198,159	$4,425,328		3629¼	2079.01	$203.18	$93.04	$78.22½

(Loss)
* % change from 1958.
s — Stock dividend.
pa — Preferred stock dividend.

[1] Fiscal year ends April 30.
[2] Fiscal year ends May 31.
[3] Fiscal year ends June 30.
[4] Fiscal year ends July 31.
[5] Fiscal year ends August 31.
[6] Fiscal year ends September 30.
[7] Fiscal year ends October 31.
[8] Fiscal year ends March 31.
[9] Fiscal year ends November 30.
[10] Not including import duties of $1,030,500.
[11] Over counter stock price is "bid."

TABLE 2. CAPITAL ASSETS, CAPITAL EXPENDITURES, AND CHARGE-OFFS.

Company	Years in business	At end of fiscal 1959: Gross fixed assets $1000	Net fixed assets $1000	Working capital $1000	Long term debt $1000	Net worth[13] $1000	Return on net worth, %	Depreciation, depletion, amortization[17] $1000	Capital and exploration expenditures $1000: 1958	1959	1960 est.
Amerada Petroleum	39	461,402	107,280	58,044	none	175,390	13.7	34,652	46,325	42,625	—
American Petrofina	4	99,177	67,241	15,175	25,774	59,689	1.7	5,848	32,198	7,647	—
Ambassador Oil	3	17,467	12,825	134	2,314	10,267	7.8	445	2,782	6,644	6,500
Anderson-Prichard	38	121,949	67,433	15,783	22,500	64,212	10.7	6,004	10,625	13,187	13,500
Argo Oil Co.	23	53,152	26,720	2,342	none	33,800	13.3	2,215	4,171	4,963	4,500
Ashland Oil & Ref.	36	230,108	88,752	47,326	24,547	126,286	11.4	14,824	14,310	16,868	24,337
Atlantic Refining	89	1,091,756	606,815	58,160	178,600	516,666	5.9	47,400	82,010	79,000	—
Aztec Oil & Gas	6	26,101	20,171	1,203	4,575	17,427	29.0	788	3,033	5,522	5,500
Blackwell Oil & Gas	55	9,453	2,429	682	none	3,643	7.2	366	569	418	425
British-American	53	573,474	353,478	88,200	54,707	417,200	6.1	34,447	81,474	70,973	59,000
Champlin Oil & Ref.	18	189,021	88,410	12,991	31,254	72,370	11.8	8,791	13,429	20,836	14,300
Cities Service	50	1,421,293	770,629	308,370	430,935	652,261	6.5	85,260	150,703	99,075	—
Clark Oil & Ref.	27	26,647	17,670	3,385	3,069	17,997	11.8	1,825	5,228	1,332	—
Coastal States Gas	4	26,038	23,339	137	16,067	8,581	18.5	840	—	13,434	14,224
Colorado Oil & Gas	8	74,450	47,802	6,186	19,942	35,477	7.1	4,469	—	6,770	5,400
Continental Oil Co.	85	1,014,030	348,669	104,606	118,821	453,277	13.3	65,941	78,773	98,994	120,000
Cosden Petroleum	20	71,242	46,283	9,641	11,450	42,923	12.0	5,822	13,314	6,850	7,000
Crescent Petroleum	41	20,454	16,482	13,826	4,914	28,904	9.0	965	992	1,482	—
Delhi-Taylor	14	70,546	39,271	12,328	34,697	20,714	13.0	4,083	4,000	4,400	12,500
Drilling & Exploration	30	31,486	13,644	2,963	325	17,028	4.5	2,172	3,201	3,991	2,653
Eason Oil Co.	46	13,753	6,699	624	362	7,183	4.7	695	1,015	867	1,300
Fifteen Oil Co.	22	10,900	6,885	898	none	7,699	6.2	559	988	1,200	—
Frontier Refining	19	20,465	13,812	1,940	7,457	9,172	8.3	1,405	2,805	3,073	3,000
General American	24	158,764	70,452	15,568	20,186	103,863	5.4	7,056	20,999[11]	22,306[11]	—
General Crude	30	48,623	16,179	9,830	none	26,009	12.9	4,513	5,099	6,752	5,530
Getty Oil Co.	31	117,188	65,126	10,344	20,481	158,699	6.7	5,653	—	10,430	9,500
Gulf Oil Corp.	59	4,381,296	2,087,563	690,656	283,402	2,631,509	11.0	260,845	510,492	335,771	386,000[12]
Helmerich & Payne	40	35,700	17,263	1,666	11,248	8,843	3.7	3,112	4,701	3,728	4,100
Honolulu Oil Co.	50	155,000	72,000	19,672	none	91,834	14.1	7,605	10,870	16,700	22,000
Hugoton Production	10	9,809	—	3,858	none	11,471	30.2	293	340	330	910
Husky Oil Co.	21	30,733	17,973	10,451	17,542	14,626	6.0	1,895	3,673	3,477	5,000
Intex Oil Co.	20	12,554	5,809	541	1,002	5,348	8.4	762	1,003	1,468	1,458[12]
Kendall Refining	78	—	7,704	5,927	none	14,215	7.0	897	891	818	—
Kerr-McGee	28	148,898	104,749	33,681	68,914	78,786	7.5	10,168	34,657	29,767	27,320
Leonard Refineries	24	26,145	16,180	6,894	4,534	17,412	7.7	1,606	3,267	518	1,500
Louisiana Ld. & Exp.	34	39,150	27,151	12,374	none	39,525	49.0	2,958	5,205	5,883	4,700
Macmillan Pet.	32	3,209	883	2,365	95	3,238	7.2	—	—	220	—
Midwest Oil	49	89,885	35,226	5,285	none	40,741	18.1	2,924	6,245	7,530	7,250
Monterey Oil Co.	9	122,873	84,292	8,284	36,850	55,282	4.5	2,304	12,013	3,301	5,800
Murphy Corp.	9	88,014	62,798	9,205	27,823	41,965	7.0	5,104	17,100	16,626	15,155
Nortex Oil & Gas	5	8,166	6,264	133	1,763	4,067	4.9	626	—	595	200
Ocean Drilling & Exp.	6	20,571	15,285	2,166	3,700	13,426	loss	1,379	—	2,493	3,150
Ohio Oil Co.	72	690,382	304,467	88,141	2,829	408,336	9.5	34,667	—	84,267	91,982
Phillips Petroleum	42	1,946,943	1,081,301	219,854	280,240	1,579,935	6.6	122,482	132,818	120,805	130,000
Plymouth Oil	36	120,300	56,746	14,637	16,407	55,973	3.9	4,798	9,733	6,421	—
Producing Properties	5	42,372	16,908	1,990	9,777	8,590	0.8	3,080	—	10,050	8,000
Pure Oil Co.	46	700,666	344,413	129,581	82,023	398,813	7.4	31,409	57,360	44,452	44,000
Quaker State	29	27,227	11,470	11,973	none	26,499	8.1	1,709	999	1,684	—
Republic Natural Gas	25	63,357	35,859	6,695	5,000	37,555	10.8	3,585	5,732	7,597	—
Richfield Oil	48	513,541	248,490	114,405	140,512	246,070	11.4	27,736	54,122[12]	63,219	—
Shamrock O. & G.	31	116,352	75,818	8,892	32,061	54,441	16.9	7,437	12,927	13,958	17,683
Shell Oil Co.	47	2,713,970	1,058,512	284,606	133,478	1,325,109	11.1	195,390	233,082	280,073	304,000
Signal Oil & Gas	37	291,947	163,521	32,254	22,006	190,249	8.5	15,771	24,600	27,500	47,768
Sinclair Oil	44	1,766,125	929,305	300,440	347,836	972,372	4.7	88,297	131,000	124,380	124,600
Skelly Oil Co.	40	638,366	306,314	52,180	3,573	362,000	7.7	37,468	62,872	60,395	—
Socony Mobil	77	3,622,896	1,852,418	686,559	173,585	2,519,787	6.5	221,605	398,000	357,000	395,000
South Penn	70	126,509	23,091	22,683	none	49,434	6.8	3,014	5,017	6,913	—
Standard Oil Calif.	81	3,184,954	1,758,732	416,474	175,000	2,120,007	12.0	141,063	343,306	399,992	400,000
Standard Oil Ind.	71	3,422,150	1,953,768	545,247	435,786	2,161,981	6.5	171,558	357,974	345,868	300,000
Standard Oil N. J.	77	9,863,120	5,960,087	1,704,439	791,642	6,687,692	9.4	67,200	1,071,650	926,146	1,000,000[16]
Standard Oil Ohio	90	485,472	251,410	72,604	56,174	280,477	8.9	25,581	40,312[14]	40,435[14]	40,000[14]
Sun Oil Co.	59	909,870	485,807	114,353	29,229	581,704	7.4	52,814	100,800	132,700	122,000
Sunray Mid-Con.	40	828,323	420,568	94,351	57,980	461,265	9.5	48,566	52,459	67,661	75,582
Superior Oil	39	323,817	218,469	25,398	89,778	156,888	12.3	11,993	72,465	56,749[15]	—
Texaco, Inc.	58	4,109,796	2,028,846	652,400	341,839	2,517,811	14.1	242,813	414,535	517,870	—
Texas Gulf Prod.	29	76,111	53,881	10,162	4,730	59,313	7.1	3,767	11,344	10,203	4,250
Texas Pacific	71	111,521	65,183	11,085	none	76,425	9.4	4,434	14,218	11,919	11,250
Three States Gas	8	23,735	15,658	1,076	8,031	5,251	0.2	722	—	3,416	1,950
Tidewater Oil	81	1,174,649	658,231	89,707	284,751	417,050	7.4	58,511	94,053	100,069	—
TXL Corp.	5	36,093	26,018	6,170	none	33,846	12.0	4,784	5,908	8,791	8,000
Union Oil Calif.	69	982,267	449,205	164,067	180,716	451,986	6.1	69,103	66,392	90,215	110,000
Union O. & G. La.	65	98,811	53,506	11,828	11,299	54,937	26.6	5,115	15,800	17,668	—
Universal Consolidated	38	27,822	11,742	7,840	none	19,582	15.6	2,180	2,125	1,051	1,500
Wilcox Oil	42	17,518	7,365	2,564	none	11,063	8.9	613	1,144	1,943	1,000
Woodley Petroleum	37	30,686	21,709	2,015	6,075	21,709	17.3	1,416	3,371	3,093[15]	—
TOTALS		50,258,410	26,456,452	7,520,622	5,212,207	30,513,175		2,360,198	4,983,718	4,923,787	4,032,275

[11]These figures on fiscal year ending June 30. Others on calendar year.
[12]Our estimate from Gulf's statement of "up perhaps 15%."
[13]Exploration estimated.
[14]Includes dry holes but not other exploration expense.
[15]Our estimate.
[16]Chairman Holman refers to "Jersey's billion dollar spending program for 1960."
[17]1959 only to compare with capital expenditures.
[18]Other assets included besides fixed assets and working capital.

Companies Seek Foothold to Climb On

Are there any trends in the industry you can discern from management reports?

There is no better place to find what companies are planning. Top management, including planning committees and economists, get in on the annual reports of large corporations. The management of smaller firms generally takes this opportunity to tell the stockowners what has happened, what the company is doing and what the president hopes for. It would take an army of interviewers to dig out the information you get in annual reports.

The 1959 reports reveal important moves by various companies that are frequent enough to form a trend. They take a picture for us of the road ahead. It's hard to know which is the most significant; probably depends on where you're standing — on how your company plans to achieve that rising curve.

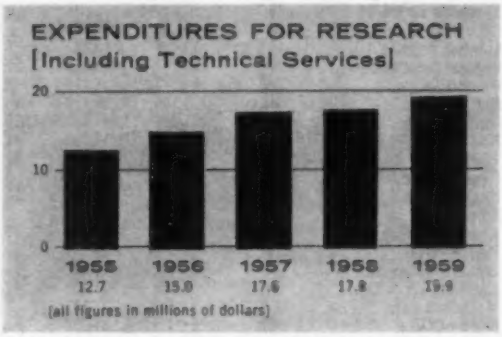
We're going to put research in the No. 1 place but you can juggle them if you wish. Here they are — the trends of the future:

1. *Research will grow and spread.*
2. *Natural gas will push its sister oil around.*
3. *Petrochemicals will add glamor as well as money.*
4. *Foreign activities will march ahead.*
5. *Balanced operations will bring new growth.*
6. *Diversification will strengthen its appeal.*

Why put research in the lead?

STANDARD OIL OF CALIFORNIA answers that question: "The company views research — both applied and fundamental — as a prerequisite to the maintenance of a competitive position in the petroleum industry."

The growing part that research plays in advancement of the petroleum industry shows up in this chart of annual costs.



Standard Oil of California

SHELL OIL COMPANY comments: "Research activities have continued to produce significant results enabling us to keep in the forefront of technological progress in our day-to-day operations and plans for the future."

We put increased research activity first because the technological evolution in which we move demands consistent programs of short and long-term research. Developments in these times have been widespread — many short steps forward, rather than a few wide jumps. The creation of new products and new uses must not dry up.

There is some hesitancy about supplying budgeted figures for 1960 research activities. One reason is that the term is not firmly defined in the petroleum industry (so many terms aren't). We have estimates of 1960 research expenditures from only 12 companies and judged by the total of these data, research funds will be 12% higher in 1960. Going further it appears petroleum R & D will spend some $410 million in 1960.

SOHIO reports: "Expenditures for research in 1960 will be the highest in company history. This will enable the research staff to step up its work on product improvement and increases its efforts in new areas such as petrochemicals, where growth in demand and the potential return on investment appear particularly attractive."

CITIES SERVICE stated: "Research activities were expanded on a broad scale. Among the most important new research projects was the construction and operation of a new pilot refinery and specially-designed mining equipment on the Athabasca River in Alberta, Canada, by Cities Service Athabasca, Inc. Purpose of this experimental facility is to determine the commercial feasibility of producing liquid hydrocarbons from the Athabasca oil sands at or near the surface."

Besides the big ones, (JERSEY STANDARD's scientific research cost $67,200,000 in 1959) there are many small companies involved in projects, sometimes using independent research firms and university science departments.

As QUAKER STATE OIL REFINING reports: "Still in the development and study phase, and continued for 1960, is cooperative research work at The Pennsylvania State University of Residual Stock Utilization, and a crude oil production research program of Miscible Phase Displacement with emphasis on the alcohol slug process.

"The Research budget for 1960 has been further increased to provide added laboratory space, equipment and experimental facilities. Most of the specialized Quaker State products marketed today did not exist 10 years ago. It is recognized that future profits can result from successful research work to gain diversification of products for changing markets."

Products, of course, are not all of research. Methods are studied in every phase of operations. The techniques of today are the results of yesterday's research.

PHILLIPS PETROLEUM measures its advancement in research and development by number of patents issued and owned. Here's the record:

COMPANY PATENTS

	Issued		Owned*	
	1959	1958	1959	1958
United States	427	298	3,527	3,169
Other Countries	328	278	1,151	895

*at year-end

Organization to use the results of research is revealed in PURE OIL'S statement: "The work of the Research Center is reported by means of frequent technical conferences, field trips to division field offices, and over 1000 technical reports a year. In the last five years Pure Oil research personnel have submitted 781 invention disclosures and have been granted 287 U. S. and foreign patents."

Could petrochemicals come to the rescue of the industry doldrums? Isn't it a stiff up-grader? Aren't profit margins better than in other products?

Petrochemicals are about the best thing that ever happened to our industry. Huge volumes are sold here and abroad. The great chemical processing plants do a good job of upgrading. But profit margins in this, too, have been whittled by fierce competition in some cases.

COSDEN PETROLEUM, which has been in petrochemicals for years, shows there are up and downs in various products although the general trend is decidedly up. Its report reads:

"In September 1952, with a design capacity of 13 million gallons a year, we commenced production of nitration grade aromatic chemicals; namely, benzene, toluene, and xylene. Last year we produced 23 million gallons of these chemicals. Unfortunately, further deterioration in selling prices occurred. Supply of these petrochemicals is likely to exceed demand for the next year or two."

On the other side, Cosden, which had a large increase in chemical sales overall, reported, "Production of paraxylene, used in the manufacture of synthetic fabrics, set a new record last year. We are quite pleased with the profitability of this operation."

Substantial increases in sales have been reported by many individual companies. Tied to increased research, potential gains could be even greater.

ASHLAND OIL AND REFINING says: "Much emphasis is being given to research and development pertaining to the manufacture of specialty products and petrochemicals, sales of which showed a 44% increase in dollar volume over last year. An important recent accomplishment is our new process for the manufacture of synthetic benzene and naphthalene by catalytic hydrodealkylation of various petroleum feed stocks."

SIGNAL, following the quickest path, bought its chemical company. It reported: "Through the Eastern States merger the company acquired a petrochemical operation at the Houston refinery, the sales of which in 1959 increased 40% over 1958. Chemicals produced here include benzene, toluene, xylene, and heptane, as well as a wide variety of aromatics and aliphatic solvents."

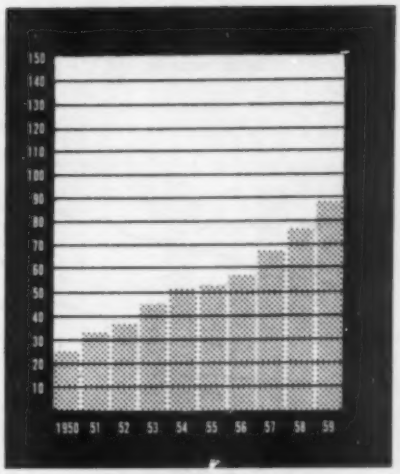
A remarkable showing was made by SINCLAIR: "The year 1959 marked Sinclair's greatest petrochemical progress to date. Sales volume was doubled over the previous year, and plans were developed for major expansion of activity."

Petrochemical plant investment strides forward. CONOCO reports: "Started construction of the world's first plant to manufacture high-molecular-weight, straight-chain alcohols from petroleum. This plant is expected to produce annually about 50,000 tons of such alcohols. They will be sold under the 'ALFOL' trademark for use in the manufacture of detergents, plasticizers, and numerous other products."

SUN is preparing for "greater participation in the field of petrochemicals, which hold promise for future years. Progress in that direction was made when an affiliate was formed and commenced operations producing polypropylene resin, films and fibers from raw materials supplied by Marcus Hook refinery. Another affiliate neared completion of its $8,000,000 urea plant and announced plans for a $15,000,000 ethylene plant."

JERSEY STANDARD gives these general figures on growth: "Demand for such oil-derived products as plastics, resins, synthetic rubbers, fibers, and detergents has been growing strongly both at home and abroad. In the United States the annual rate of growth has been 14% in recent years, and it is expected to continue at not less than 10% for the next several years."

Actual 1958 vs 1959 chemical sales



NATURAL GAS REVENUE (U. S.)
millions of dollars

Phillips Petroleum

Gas revenues increased steadily for many companies. Natural gas is a step-child no longer.

for 11 large companies in our survey show a 20% increase last year. Only one of these had a decrease and it was very slight.

Most of these figures are international and probably indicate greater increases in demand abroad than in the U. S.

What has natural gas contributed? It should be pretty hamstrung by regulation.

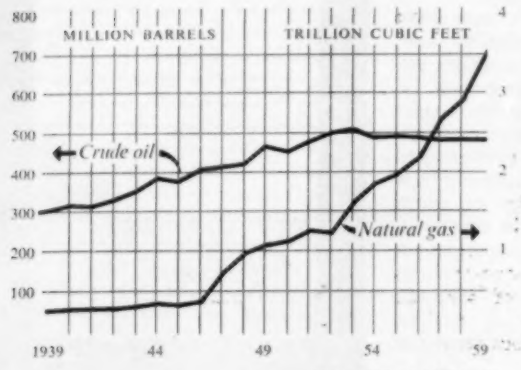
There was more natural gas found and more produced in 1959 than ever before. UNION OF CALIFORNIA gives a good example of how gas is catching up with oil (see the chart next page). A production curve in the same report was very similar. Oil is rocking along but gas is sprinting ahead.

PHILLIPS, which has large natural gas reserves, stated: "Our natural gas business in the United States continued the long-term trend of growth in volume, prices, and income. Gross income derived from Phillips sales of natural gas increased 15% over 1958 to an all-time high of $88,900,000.

"Increased sales volume and higher prices are expected to result in greater income in 1960. Phillips continues to seek new sales of natural gas in intrastate markets, where prices are not subject to uncertainties of Federal regulation."

TEXAS PACIFIC COAL AND OIL is pleased with its gas sales: "Further evidence of our operational flexibility is found in the continued increase in our gas sales. As price and profit margins indicated an increasing emphasis on natural gas production and sale, we

Net crude oil and natural gas reserves



Union Oil of California

This curve and one on production were similar. Gas pushing up, oil leveling off. Several companies gave reserve curves in 1959.

increased our sales 54% in 1958 over 1957, and in the past year increased them again 65% over 1958."

EASON OIL COMPANY's report shows that gas production can be shut-in. Its report was: "In 1956 the management decided as a matter of policy to divert a substantial portion of exploration and development funds from oil into gas. It then appeared that a gas market would be available within a year or slightly longer. That has not been the case, and the reserves of Eason Oil Company in northwest Oklahoma will be shut-in until the purchaser with whom we have contracted receives governmental authority for the construction of their facilities."

UNION OIL AND GAS OF LOUISIANA stated: "Sales of natural gas continued to increase during 1959. The higher volume coupled with a slight increase in the average unit price resulted in a gross gain of 42%."

You say foreign operations by U. S. companies are expanding. How do you explain that when supplies are more than ample?

TEXAS GULF PRODUCING COMPANY, one of many smaller firms that has ventured abroad, explains it this way: "The paradox that now exists in this country is that finding costs have risen to new heights; bonuses, royalties and rentals for wildcat leases continue to climb and, instead of price increases for products and crude which economics would normally dictate, we have been faced with price reductions. This has been caused mainly by the importation of crude oil and its products in quantities detrimental to the domestic industry, and the taking over of many energy markets by low-priced natural gas. Gas prices are controlled by the Federal Power Commission and in most instances are below fair market value.

"Under these circumstances, the management of your company decided we should look for oil in areas of the world that are accessible and where the chances of finding cheaper oil would be greater than in this country. Our effort in exploration and development, therefore, is now being concentrated in Libya with a corresponding decrease in expenditures in the U. S."

CITIES SERVICE, which wouldn't be called an international company, reports: "Foreign exploration and development were further expanded during the year. Substantially all of this expenditure was charged to current income. Cities Service now participates in 74,353,000 acres of foreign holdings in 10 countries in which the company's net interest is 24,049,000 acres.

"In furtherance of the company's policy to obtain foreign production for long-range supply, several new concessions were obtained, in association with others, in Africa, Spain, Italy and other overseas areas."

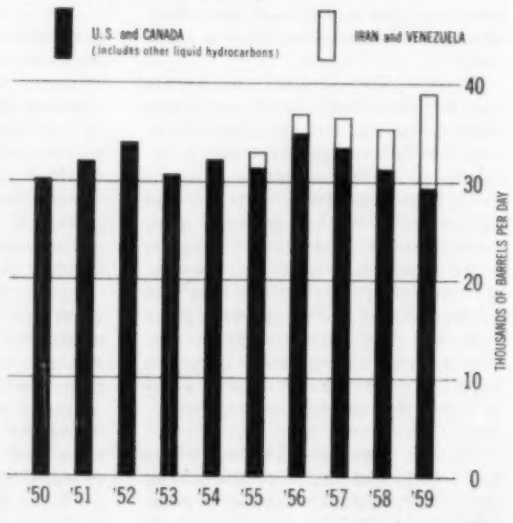
BLACKWELL OIL AND GAS COMPANY is taking a flyer in South America. The president reports: "To provide balance to our expanding domestic leasing and exploration activities, the company continues to explore judicious entry into foreign areas. The first phase of our geological evaluation of our Bolivian concessions has been completed."

THREE STATES NATURAL GAS said: "Continuing its program of replacing tested acreage with new prospects, Three States moved into both Australia and Canada during the year."

Although there have been great successes in foreign operations failure is expensive. As PLYMOUTH OIL said: "One of the largest factors in the company's depressed earnings was the unusually large charge-off for well abandonments, a considerable portion of which can be attributed to the cost of the exploratory project on the Ivory Coast of French West Africa."

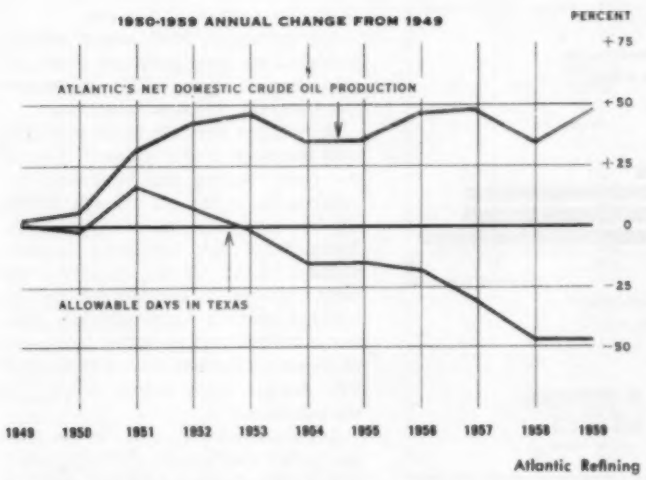
RICHFIELD points out that the geography of oil has changed. The president told stockholders: "I have made reference to the fact that the geography of oil was changing and that due to low-cost oil production abroad and cheaper unit costs of transportation resulting from the construction of large tankships, the Pacific Coast was losing its position of relative isolation from a competitive standpoint. This trend has continued to the extent that the Pacific Coast industry is now subject to competitive factors that have no geographical limits."

CRUDE OIL PRODUCTION rose to a record level in 1959.

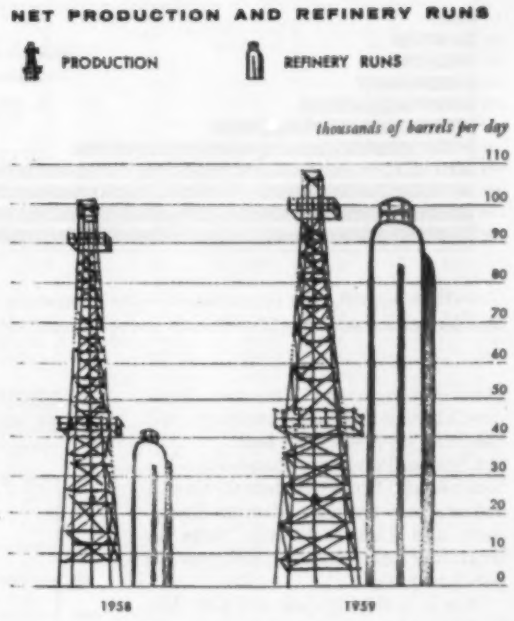


Standard Oil (Ohio)

Sohio shows the trend to foreign operations. First oil outside of U. S. came in 1955. Now the company has many times as much from foreign areas. At the same time domestic crude oil output is lowest in 10 years.



Balanced operations are believed to help efficiency. Atlantic, with large refining capacity, shows by curves how the company has improved its crude oil production.



Predominately a producing company, Ohio bought refineries to balance production and refining capacity.

Do balanced operations simply mean integrated companies?

As a rule integrated companies are striving the hardest for more balanced operations so it means more than integration. It means keeping operations in the line that reaps the best economic results.

ANDERSON-PRICHARD explains this very well: "Security and growth in the oil business have been best typified by the companies engaged in all of its branches. Anderson-Prichard is dedicated to full integration and is improving its position in all departments on a year-by-year basis. The company continued to expand programs designed to better integrate the activities of exploration, production, refining, transportation and marketing."

Take the case of ATLANTIC REFINING, which has been developing production to match its refining capacity.

". . . specific improvements achieved in Atlantic's raw material position . . . can best be summarized by reporting that during the last five years: Our reserves of crude oil have increased by 62%, and reserves of natural gas by 64%; crude production, despite governmental restrictions, has increased 37% and gas production 40%. Most important of all, our self-sufficiency ratio, the relation of crude produced to refinery runs, rose from 52% in 1955 to 71% in 1959."

In the opposite direction OHIO OIL COMPANY jumped its refining capacity in 1959 to come close to its producing capacity. It reported: "The integration resulting from bringing refining and marketing operations essentially into balance with domestic crude oil production provides our company with much more flexibility. It also enhances our ability to market crude oil which we expect to be producing abroad within the next few years."

Several firms have been expanding marketing facilities to balance refinery runs. AMERICAN PETROFINA states: "In furthering the company's objectives to balance sales outlets with refinery throughputs, a proportionately larger share of capital funds was allocated to marketing."

This is the way the balancing effort worked for MURPHY CORPORATION: "In addition to earning acceptable returns on investment in their own right and contributing materially to net profit, these marketing properties and the newly acquired refinery have supported the crude-oil-producing department both as to price and volume."

CLARK OIL AND REFINING CORPORATION recalled: "As an initial move in the direction of establishing an integrated petroleum operation, your company, early in 1957 opened an Exploration and Production Division in Denver, Colorado. Since then it has engaged in exploratory work which has as its objective the production of a significant portion of the company's crude requirements."

The trend toward balanced operations has inspired scores of mergers and purchases. Sometimes the acquired properties were to extend in area as well as in operations.

PRODUCING PROPERTIES tells its shareholders: "Competition for the purchase of producing oil and gas properties has increased keenly in the past year, particularly from major oil companies who have been willing to issue for the acquisition of such properties, dividend-paying, listed securities on a tax-free basis and in some cases have been willing to pay large cash amounts. It is expected that such competition will continue; nevertheless, it is felt that this corporation will continue to grow as it has in the past." (Oceanic Oil was purchased by Producing Properties.)

SUNSET INTERNATIONAL explains: "The steadily rising cost of exploring for oil and gas adds to the wisdom of buying production on the best possible terms and applying maximum engineering skills to increase production and reserves."

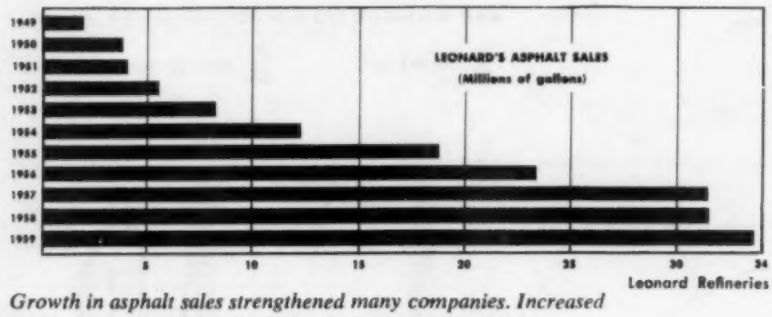
SUNRAY MID-CONTINENT effectively illustrates its growth by acquisition on one page of its report. It has purchased 17 companies since 1920—some large (Barnsdall 1950 and Mid-Continent 1955) and some small. In 1959 Suntide and Gafill were added.

That new concerns spring up almost as rapidly as others are merged is in evidence in Table 2 where the number of years in business is given for each company.

What about diversification?

Diversification is branching into other business and industry. When the petroleum industry was booming we had money flowing freely from other industries into ours. Now there is the beginning of a reverse trend.

Signal, for instance, owns Scudder



Growth in asphalt sales strengthened many companies. Increased highway construction will obviously improve sales further.

Food Products and American President Lines, a steamship company, and has done very well with both.

Crescent Petroleum Corporation has four small firms — General Switch, Eastern Air Devices, Metalab Equipment and Kurman Electric. Sales for these four rose 41% in 1959 over the previous year.

Sun is in shipbuilding and Kerr McGee has an uranium mill operation.

Colorado Oil and Gas, which has grown rapidly by acquisitions, bought Marsh Instrument Company late in 1958 and sales of this division increased 25% in 1959.

Using the oil and gas business as a base, some companies have added subsidiaries outside their industry to make use of organization surplus.

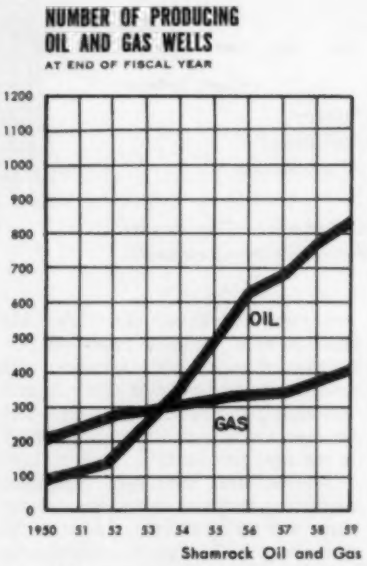
Has the national highway program helped the oil business?

This is pretty intangible. You have to set highway construction help against depressed demand because of oil product taxes to pay for highways. It's hard to bring into balance. We can't even prove that high gasoline taxes have contributed to small car popularity but it sounds reasonable.

The factor most definite so far as highway construction is concerned, is asphalt sales. They are certainly on the increase. LEONARD REFINERIES devotes two annual-report pages to boosting asphalt for new highways. One paragraph reads:

"Leonard is one of the largest suppliers of asphalt in Michigan. As construction of new highways in our marketing area continues and worn out concrete highways are salvaged by resurfacing with durable asphalt, the company's manufacturing and distribution facilities are fully prepared to provide quality asphalts quickly and economically."

DOUGLAS OIL COMPANY of CALIFORNIA has had good experience with asphalt: "On the brighter side of the Douglas operations for the fiscal year was its asphalt sales, which were the highest in the company's history."



More companies give operational data in annual reports.

Have operations changed much?

Operations are vastly improved—due largely to expanded automation. Computers have been the key here. SOCONY MOBIL explains: "Socony Mobil's electronic computer network put into operation in the United States last year provides instantaneous communication among three computer locations in this country. Computers solve such problems as determining the probable life of an oil field, figuring the best processing pattern for crude oil in a refinery, and establishing the most efficient distribution pattern between refineries, terminals, and bulk plants."

AMERADA reported these things: "Among the important efforts which the company is actively pursuing are applications of technological advances in exploration, drilling and production methods; wider well spacing to permit the efficient draining of oil fields with fewer wells; multiple-zone completions and the pressure maintenance and secondary recovery methods, which make additional reserves at low cost.

Our survey of 1953 annual reports indicated the great potential growth of secondary recovery. This movement has faithfully followed predictions.

MONTEREY provides its shareholders with the story of one project: "One of the most exciting and interesting developments in the oil industry within the last few years has been the establishment of the automatic custody transfer of oil. In this, Monterey has been a pioneer as operator of the Fullerton Clearfork Unit, utilizing automatic control and metering equipment to eliminate the necessity of putting oil into storage tanks before delivery to the purchaser."

GENERAL CRUDE says: "It has been our policy to effectuate operating economies and increase ultimate recovery of crude oil reserves through wide spacing of wells and pressure maintenance whenever possible."

SOUTH PENN reports: "During the year 1959, the company continued its efforts to increase reserves through improvement of production methods."

Good economics is told by TEXAS PACIFIC in dollars-and-cents results: "Through close supervision of expenditures, the company was able to hold operating costs per barrel of crude oil to 70.6¢, only slightly more than the 69.0¢ in 1958. Costs of labor and materials continued to increase, but higher total production kept the per-barrel cost from increasing proportionately. The total of 70.6¢ included lifting costs of 34.6¢, general field expense of 11.6¢, production taxes of 17.2¢, and ad valorem taxes of 7.2¢ per barrel."

Specializing in offshore operations OCEAN DRILLING and EXPLORATION says its "engineers have continued research and design efforts in an attempt to solve some of the remaining technical and operating problems, particularly deeper water drilling methods and new approaches to offshore production.

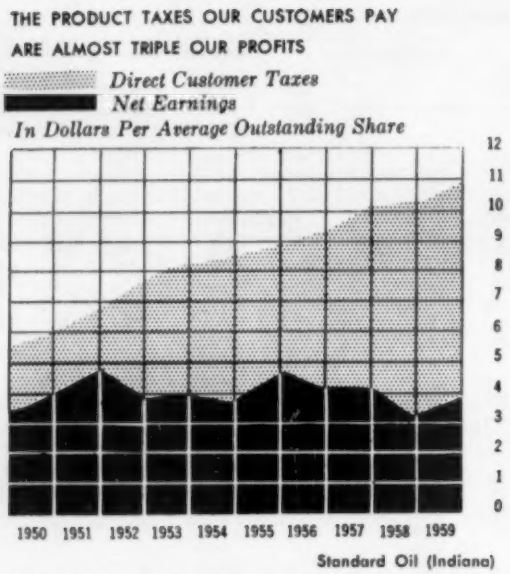
Liquid petroleum products receive continued attention. UNION OIL OF CALIFORNIA stated that it and another company "are building facilities to extract and process butane, propane, and other liquids from our southern Louisiana natural gas production. These products will be sold to the oil and chemical industries, providing the company a new source of revenue."

Several examples are given of more efficient pipeline operations. Here's one by GULF OIL: "Significant progress was attained in our program to reduce costs through the modernization of crude and product pipelines. Highlighting this program is the installation of automatic equipment and measuring devices for the operation of facilities by remote control. The West Texas Gulf Pipe Line Company, a 58%

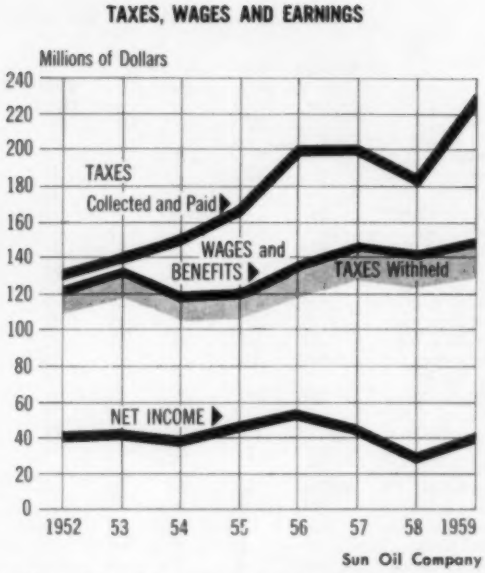
TABLE 3. OIL AND GAS OPERATIONS — 1959

Company	Net lease or fee, dev. or undev., 1000 acres	Net wells drilled 1959[a]	Net producers		Wildcats, net	Discoveries, net	Net producing wells owned	Net Production			Refineries Owned		Estimated Reserves	
			Oil	Gas				Crude oil b/d‡	LPG b/d‡	Gas MM cf/d‡	Crude oil capacity b/d‡	Crude runs b/d‡	Oil[12] million bbl	Gas, billion cu ft
*Amerada	6,561	247	130	25	—	—	3,535	82,478	—	—	none	—	31	230
*American Petrofina	451	35	—	—	13	2	1,072	9,312	—	42.2	50,000	39,173	—	—
*Ambassador	767	80	44	4	36	11	400	4,754	—	7.5	none	—	19.6	46
*Anderson-Prichard	962	81	47	7	21	7	1,166	14,175	—	39	37,500	30,074	—	—
Argo Oil Corp.	1,024	41	10	5	25	2	514	13,051	95	39.1	none	—	82[1]	205[1]
*Ashland O & R	497	51	20[2]	—	24	3	3,108	21,000	—	—	166,500	136,576	255	31
*Atlantic Ref.	9,651	288	197	27	57	21	4,809	137,699	—	570	210,000	194,819	776	3,654
Aztec Oil & Gas	479	86	40	43	—	—	378	6,821	—	37.8	none	—	19[1]	798[1]
*Blackwell O & G	825	8	6	2	2	1	303[3]	1,288	—	2	none	—	—	—
*British American	17,746	210	86	18	82	13	1,761	60,548	1,127	161.6	165,600	124,950	430[1]	3,650[1]
*Champlin O & R	2,261	105	49	16	32	5	1,438	14,247	8,336	286[5]	31,000	27,054	—	—
*Cities Service	24,049	376	—	—	77[4]	24	—	124,745	—	868	313,000	280,000	—	—
Clark O & R	—	—	—	—	—	—	—	—	—	—	30,000	30,408	—	—
*Coastal States	143	42	11	23	11	4	132	542	235	19.5	none	—	10	427
*Colorado O & G	1,265	33	15	3	13	2	1,048	6,681	—	49.3	20,000	17,200	—	—
*Continental Oil	14,451	616	470	5	76	16	7,475	178,639	11,877	441.3	154,200	180,867	—	—
Cosden Petroleum	173	29	21	4	4	0	525	5,720	—	9.2[5]	43,000	38,893	24.3	37
*Crescent Petroleum	433	—	—	—	—	—	303	3,623	—	6.8	none	—	—	—
*Delhi-Taylor	260,516	32	24	5	6	3	474	5,945	—	137[6]	47,500	41,000	48[1]	3,026[1]
*Drilling & Exp.	544	33	15	3	14	2	467	3,391	157	7.4	none	—	—	—
Eason Oil Co.	120	5	1	3	4	1	256	1,499	—	6	none	—	6	70
Fifteen Oil Co.	80	16[4]	8	3	—	—	—	2,000	—	4	none	—	—	—
*Frontier Refining	245	13	11	1	—	—	—	1,500	—	3	20,000	19,200	3	10
*General American	610	210[7]	88	3	14	2	2,990[8]	23,178	—	—	none	—	118.8	283.8
General Crude	1,410	59	8	5	50	8	470	9,500	—	22.3[5]	none	—	—	—
*Getty Oil Co.[17]	350[9]	34	31[2]	—	—	—	696	65,166	333	1,065[6]	50,000	25,700	—	—
*Gulf Oil Corp.	105,044	1,502	1,111	74	229	66	19,028	1,304,183	122,097[6]	952[9]	532,237	685,101	—	—
*Helmerich & Payne	227	49	38	2	14	—	661	3,914	—	21.3	none	—	16.7	291
*Honolulu Oil	4,227	172	126	8	40	8	1,562	43,300	3,200	78.3	none	—	—	—
Hugoton Production	161	5	—	5	0	—	164	none	1,334	110.9	—	—	—	1,250
*Husky Oil	383	10	7	0	2	½	177	5,462	101	7.1	7,000	5,828	—	—
Intex Oil	185	20	9	1	12	2	140	2,705	—	—	none	—	13.5	1.3
Kendall Refining	—	33	—	—	—	—	—	1,016	—	—	4,800	4,159	—	—
*Kerr-McGee	1,596	26	6	8	12	1½	671	5,354	3,946	136	43,000	42,668	25.3	112.1
Leonard Refineries	—	—	—	—	—	—	—	—	—	—	29,000	25,500	—	—
Louisiana Ld. & Exp.	725	12	10	1	2	1	113[10]	26,004	—	53.9[6]	none	—	—	—
Macmillan Pet.	—	0	—	—	—	—	—	87	—	—	13,000	9,322	—	—
*Midwest Oil	642	56	24	3	29	7	903[1]	18,403	—	42	none	—	—	—
Monterey Oil	467	28	19	1	8	1	670	15,054	7,190	38.7	none	—	66.3	59
*Murphy Corp.	1,655	48	32	4	11	2	398	10,761	994	41	15,000	8,211	—	—
*Nortex O & G	12,448	—	—	—	—	—	98	1,118	—	—	—	—	7.2	23.3
Ocean Drlg. & Exp.	15	8	1	2	5	1	9	shut in	—	—	none	—	—	—
*Ohio Oil Co.	39,733	252	161	26	52	9	10,558[7]	97,887	11,411	301.3	110,000	100,268	672.4	2,274
*Phillips Petrol	36,784	293[9]	198	40	20	8	8,867	164,853	97,807	2,799	287,100	237,182	1,400[11]	17,700[11]
*Plymouth Oil	31,335	38	20[2]	—	—	—	1,367	14,986	—	88	45,000	31,000	—	—
*Producing Prop.	201	5	3	0	0	—	944[4]	7,288	159	21[6]	none	—	37.4	127
*Pure Oil Co.	6,741	219	140	19	53	15	5,031[9]	65,636	4,762	293	185,500	166,355	511	2,194
Quaker State	—	73[13]	—	—	—	—	—	1,392	—	—	10,300	8,543	—	—
Republic Nat. Gas	1,071	47[7]	21	9	17	5	864	7,845	—	162[6]	—	—	—	—
*Richfield Oil	6,259	142	95	3	35	3	1,471	72,164	—	—	165,000	137,814	—	—
Shamrock O & G	736	141	58	40	91	54	1,161	5,530	9,429	205	25,000	21,214	85	1,700
*Shell Oil Co.	13,061[9]	1,053[4]	671[1]	144[4]	209[4]	57[4]	9,647[14]	316,000	—	941[6]	594,000	490,000	1,500[1]	6,700[1]
*Signal Oil & Gas	3,580	30	25	0	8	1	1,227	63,900	6,500	36.4[6]	70,000	86,300	—	—
*Sinclair Oil	9,943[9]	414	248	59	91	29	9,711[15]	177,359	—	392.2	499,000	441,718	—	—
*Skelly Oil Co.	6,070	355	221	45	58	17	5,577	64,465	21,705	347	—	48,882	—	—
Socony Mobil	9,276[9]	466[15]	339	62	70	20	17,216[15]	749,000	27,000[9]	1,046	915,000	939,000	9,125	10,515
South Penn	860	228	129	1	98 serv.	—	12,477	8,194	—	—	12,000	9,676	39.6	42.4
*Standard Oil Cal.	71,546[16]	614[16]	432	38	95	28	9,922[16]	884,010[1]	—	667.5	680,500[16]	788,461	—	—
*Standard Oil Ind.	15,353	837	526	118	170	52	13,432	307,686	—	1,567	707,400	598,280[12]	2,243[16]	13,269[16]
*Standard Oil N. J.	252,700	1,273	—	—	332	—	28,800	2,464,000	—	1,526[9]	—	2,788,000	—	—
*Standard Oil Ohio	1,734	74	34	5	27	4	2,007	34,864	4,077	87	170,500	136,988	110	650
*Sun Oil Co.	19,247	437	198	79	—	—	—	129,403	—	210	270,000	232,356	910	4,400
*Sunray Mid-Con.	23,340	249	139	31	70	20	5,088	78,515	7,616	375.3	175,000	154,026	402[9]	2,566
*Superior Oil	—	120[14]	98	—	—	—	—	93,830	7,216	538	none	—	—	—
*Texaco Inc.	52,237	1,542	1,149	150	—	—	—	1,221,537	31,555	1,291[6]	1,001,100	1,219,034	3,845[16]	14,108[9]
*Texas Gulf Prod.	197	—	—	—	—	—	—	13,800	1,350	32.7	none	—	—	—
*Texas Pacific	1,314	93	78	5	8	1	1,700	20,139	880	49[6]	none	—	—	—
*Three States Gas.	7,156	11	6	3	3	1	317	3,479	—	38.3	none	—	14.3	449.6
*Tidewater Oil	25,010	390	304	35	42	9	5,737	97,051	16,325	349	280,500	195,196	693	3,509
TXL Corp.	1,973	96	76[2]	—	14	3	304	11,331	—	26.9	none	—	—	—
*Union Oil Calif.	3,325	210	85	45	74	19	3,962	91,876	6,571	288	188,800	172,700	488.3	3,501
*Union O & G La.	818	34	16	8	9	2	335	15,130	3,295	244	none	—	—	—
Universal Consol.	260	15	7	0	4	0	313	6,344	157	7.5	none	—	—	—
Wilcox Oil	186	50[4]	33[2]	—	—	—	524[4]	3,277	—	15.7	none	—	15	55
*Woodley Petroleum	640	—	22	—	—	—	396	9,477	—	10.9	none	—	70	70
TOTALS		14,570	8,256	1,309	2,575	574	216,880	9,451,295	418,857	19,337		10,975,704		

*Has foreign interests.
‡Calendar day.
[1]Estimate made before 1959. Later one not available.
[2]Oil and gas.
[3]Operates.
[4]Gross.
[5]Includes wildcats.
[6]Sales.
[7]Including service wells.
[8]On June 30, 1959.
[9]U. S. only.
[10]Also royalty interest in 985 wells.
[11]As of February 7, 1957.
[12]Includes natural gas liquids.
[13]Includes renovated wells.
[14]Wholly owned.
[15]U. S. and Canada.
[16]Western Hemisphere.
[17]Data does not include Getty interests in other companies.



This shocker explains why taxes were tabbed Trouble No. 1 in 1959. Uncle Sam takes 3 to 1 for the company that finds, refines, and markets the products.



Another vivid picture of who gets what in the oil business. Taxes are more than net income (the Cinderella column) combined with wages and benefits.

owned subsidiary operated by Gulf, will complete the installation of this type of equipment early in 1960, at which time the flow through the entire system will be controlled from Houston, Texas."

What are the biggest problems mentioned in annual reports?

It is odd, with all the special industry problems, that the one mentioned most is one common to all industry today—taxes. Here are four problems that were discussed most frequently:

1. *Taxes*
2. *Imports*
3. *Gas Controls*
4. *Depletion*

SUNRAY MID-CONTINENT is one that lists all four and gives brief explanations of each "in order that shareholders may be aware of the more critical areas of government relationship faced by the oil industry."

About taxes, here are a few management opinions.

SOUTH PENN OIL COMPANY: "Taxes have become an increasingly onerous burden on both the oil industry and the consumer."

STANDARD OIL COMPANY (OHIO): "We believe that the tax burden on the motorist is disproportionately high. We are concerned about the tendency of government to let 'temporary' tax increases become permanent, and about the detrimental effect that this is bound to have upon the sales volume and earnings of Sohio and other companies."

WILCOX OIL COMPANY: "... increased taxes by the Federal Government have made the going rough."

OHIO OIL COMPANY points out that consumer taxes have the same effect as taxes on the company: "Regardless of their form, all these taxes constitute a direct levy upon our business. Our tax payments in 1959 totaled $57,200,000. This amount is equivalent to $4.09 per share." (Net income $2.76.)

STANDARD OIL (INDIANA): "Legislators must realize that we are approaching — if, indeed, we have not already reached—the point where heavy excise taxes reduce gasoline consumption."

SUN OIL: "The tremendous sums collected and set aside annually by Sun for tax payments to all levels of government now exceed by a wide margin the combined total of net income and wages and benefits to employees."

In our opinion, taxes are the heaviest weight on progress of the petroleum industry at this time. Its operations carry higher taxes than most luxury items. There seems to be no effective means of halting the rising tide.

In Table 2, direct taxes on oil companies show a 10.4% increase over 1958 and excise taxes have grown about 10.3%. We've reproduced two effective charts that present a good visual picture of the disportionate tax burden on petroleum operations.

The second problem, imports, has been with us for decades and it continues to divide the industry as each company takes the stand closest to its own interests.

AMERICAN PETROFINA reports: "In March 1959, the Government extended appropriate recognition to the importance of inland refiners in national defense and to the economic threat which the excessive imports created."

STANDARD OF CALIFORNIA explains that the import question affects more than the U. S. in this time of oversupply: "Government oil import restrictions limited the amount of foreign crude oil and products which could be marketed in the United States, further contributing to the competitive pressures overseas."

REPUBLIC NATURAL GAS COMPANY was skeptical about results: "Mandatory controls over importation of foreign crude oil have not had the desired effect to date of bolstering the demand for domestic production. Allowed producing days in Texas remained at the depressed level of the previous year, 134 and 131 days, respectively, as compared to 189 for fiscal 1957. Oil production was curtailed further by decreased allowable in Kansas, Oklahoma and the Rocky Mountain area."

As we said before, perhaps the great thing about oversupply and its attendant problems is the stability it reveals. Somehow the market balances without any one segment suffering much more than another. We've escaped so far the roller-coaster prices of early days.

If natural gas controls are so bad, why do gas sales keep expanding?

Let's say that controls become more harrassing as the gas business grows.

AS SHAMROCK OIL AND GAS relates: "The regulation by the Federal Power Commission of independent producers following the Supreme Court's decision in the Phillips case continues to be

burdensome, expensive, and time-consuming to independent producers. We again express the hope that Congress will recognize these burdens, not only in the interest of the producers but the consuming public, and adopt effective remedial legislation."

Shamrock's hope is on the wishful side. Companies, confused as they are by gas operations, are not predicting any relief from controls this year.

GENERAL CRUDE clarifies its position: "In the large majority of cases the FPC has not ruled on rate increases, but has allowed the producer to collect amounts provided for in his contracts; however, revenues received in this manner are subject to refund with interest if the Commission later rules that a producer's price is excessive. Because of this governmental intervention, it is almost impossible to enter into an interstate contract with any certainty in regard to price."

Will percentage depletion always be a problem?

Depletion is always with us. PURE OIL COMPANY states the situation very well: "Since percentage depletion is a unique tax provision applicable only to petroleum and other extractive industries, it has frequently been the subject of investigation and criticism by some members of Congress. This is largely due to a tendency to regard it only as a tax deduction not available to others rather than a tax recognition of a special problem not faced by others."

ARGO devotes a whole page "In Defense of Depletion." An excerpt is: "Percentage depletion is an established, long-standing provision of the nation's tax laws. It allows the owner of a natural resource to recover the value of his capital from the proceeds of the sale of that resource. Capital is not taxable as income under present tax laws."

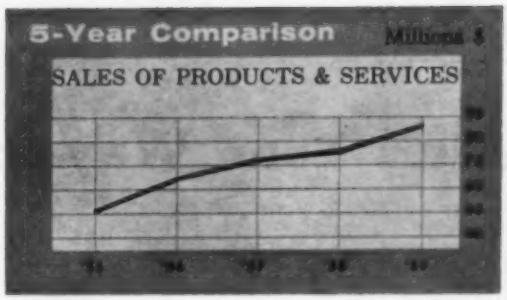
If you'll check the depletion, depreciation and amortization column in Table 2, you'll find that in 1959 it was about half what capital outlays were.

This means that all deductions for capital investment are not enough for replacement. It is the reason in many cases that shareholders receive stock instead of cash. To maintain modern facilities—without expansion at all—requires either that a large amount must be taken from earnings or that funds must be procured through some form of borrowing.

REPRINTS

You may obtain reprints of the annual survey of the petroleum industry for 50 cents a copy (less in quantities).

Readers Service Dept.,
The Petroleum Engineer
Box 1589, Dallas, Texas.



This curve is typical of the industry as a whole. It has sold more products and services each year and outlook is for continued growth.

Clark Oil and Refining

OUTLOOK

Then what about the outlook? Where do we go from here?

The best way to learn that is to take a look at management opinion. Better than any commentator, company managements know what faces the industry and what will be done. They all breathe confidence. They think they have it made. The upward curve may waver but, so far ahead as they can see, the industry can profit by growing. Here is what they say.

STANDARD OIL (INDIANA): "We do not agree with the pessimistic view of some observers, who contend that increases in demand will be insufficient to correct the imbalance with supply for an uncertain, perhaps long period ahead. Their view is largely based on estimates that demand will grow at a slower percentage rate in the sixties than in the fifties. What is often overlooked is that even these cautious percentage estimates add up to a remarkable volume growth."

PLYMOUTH OIL: "Although it is made painfully aware of current depressed conditions in the oil industry and sees no immediate stabilization of supply and price factors, the confidence of the management of Plymouth Oil Company in the long range future of the oil industry remains undiminished. It believes that an increasing population and new markets and new uses for petroleum products will bring about a demand that will eventually solve the problem of over-supply."

BRITISH AMERICAN OIL COMPANY: "Outlook for the petroleum industry in 1960 has many encouraging aspects. Production of crude oil and condensate in Western Canada in 1960 should show an increase in excess of 10% over 1959 with the prospect of increased demand in both domestic and export markets. Consumption of natural gas within Canada will continue to grow."

AMERICAN PETROFINA: "Stability and progress within the domestic petroleum industry are dependent in large measure on top management. Reasonable profit margins are certainly possible and can be expected provided the new supply of oil products is constantly adjusted to correspond with current demand and existing inventories. Unfortunately, the unrealistic philosophy that incremental volume will return additional profits has too often prevailed and has encouraged refinery runs approximating capacity levels irrespective of product requirements. This practice almost inevitably results in surplus stocks and distressed markets."

TIDEWATER OIL: "Even in these depressed times, when some critics are marking oil down as a faltering industry, we consider oil a growth industry. This is supported by all economic forecasts for oil and energy demand for the next decade and, in fact, for the next century. The oil industry is and will continue to be a vigorous, expanding industry."

TEXACO: "We are expecting the demand for petroleum products to increase this year by 4% in the United States and by 8% in the rest of the free world. Statistically, the oil industry seems to be moving toward a sounder inventory position and, with consumption of petroleum products in the free world increasing at a rate of approximately one million barrels a day each year, we look forward to 1960 with confidence."

CITIES SERVICE: "Even in the next 15 years, competent authorities estimate, the world's energy demand will be double that of today, with petroleum and natural gas called upon to supply a major portion of this requirement. In view of this, it seems certain that the oil and natural gas businesses, in which Cities Service is principally engaged, have outstanding growth potentials in the years ahead." ★ ★ ★

HOW TO BE A MANAGER

Speaking Your Way to Success

Orville Roberts, Jr.

"Speech is civilization itself. The word, even the most contradictory word, preserves contact — it is silence which isolates." — Thomas Mann

RHETORIC IS AN INGREDIENT of history. THE WORD, both spoken and written, has, throughout human experience, set in motion and given direction to the great movements in politics, religion, war, social expansion, industry, and education. THE WORD is the touchstone of business. It is the medium through which we plan, organize, motivate, coordinate, control and train. It is the means through which we inspire men and women to action. It is the means through which we placate aggravation. It is the means through which we guide the destinies of the market place.

It is a temptation to say that a man cannot be a fine manager without possessing facility in the use of language. The temptation must be resisted, because a man cannot be even a mediocre manager without a command of the spoken and written word.

This article is one of a series of articles published during the past year by *The Petroleum Engineer* regarding "How to be a Manager." It would be instructive to glance again at each of the chapters and notice that none of the objectives can be achieved without the vehicular use of the tongue or the pen. The manager, therefore, should not regard speaking as an isolated tool, but rather as a skill necessary for the implementation and execution of ALL tasks which it falls to him to perform. It follows, surely, that the refinement of the manager's ability to speak prepares him to discharge more perfectly the many facets of his responsibilities.

ORVILLE ROBERTS, JR., *manager of Organization and Personnel Development, Sinclair Pipe Line Company, Independence, Kansas, is a nationally prominent public speaker. He has addressed more than 1500 audiences from coast to coast during the past 15 years. Mr. Roberts was educated at the University of Kansas, from which he received Bachelor of Arts and Master of Arts degrees, and served on the faculty of that University. In addition to his work in planning and administering his company's personnel development program, he has had significant experience in industrial education, having served as advisor and instructor for the Steel Institute and the Credit Institute.*

A member of the American Society of Training Directors Mr. Roberts is listed in the Directory of American Scholars. He is a member of the Independence Rotary Club, Delta Sigma Rho, Pi Sigma Alpha, and Sachem. He is past president of the Independence Community Chest, and was named "Young Man of the Year" by the Independence Jr. Chamber of Commerce in 1957.

Scratch the surface of a good speaker and you will find a potential manager . . . and vice versa

TAKE A LOOK AROUND

Pick out the five most successful persons in your organization. Make an analysis of the reasons for their success. Is there even one of these persons whose command of the language, either across the desk or the conference table, or from the platform, is not outstanding? These men may not THINK of themselves as speakers. They may not have the REPUTATION of being speakers. But they undoubtedly ARE speakers in the sense that they possess the ability to achieve action, through other persons, by the use of the spoken word.

TAKE A LOOK AT YOURSELF

We have all been endowed with the equipment needed to command action through speaking. We have all been given a voice through which we may PROJECT ideas, a mind through which we can CONCEIVE ideas, and the equipment for RESPONDING TO ideas. Some of us may feel that our voices are not perfect as far as timbre and pitch are concerned; we may feel that we cannot think of things worth saying; we may feel that we are not endowed with the magic gifts which make a speaker.

Let us remember that a voice need only be pleasant and of adequate volume to be sufficient as an instrument for projecting ideas. Let us remember also that some hard, private thinking about the subject at hand will enable us to develop something worth saying to others. Let us also remember that speaking is not like a magician's performance, that it does not involve sleight-of-hand, that it is not a gift bestowed by the gods on a select few. It involves nothing more than taking an idea, phrasing it in simple and

Good speakers are never mechanical

direct language, and projecting it through the voice to an audience. It is just as simple — and as wonderful — as that.

Hundreds of books have been written about the art of public speaking. Volumes have been written about how to organize talks, how to secure speech material, how to project the voice, how to improve the vocabulary, etc. Do not be excessively concerned with these multitudes of details.

Talking together is essentially a simple process. It springs from sincerity and belief. It is based on conviction and concern. It is most perfect when it is least mechanical. It is most convincing when it is least "artful."

Remember the verse in the nursery rhyme:

"A centipede was happy quite
Until a frog in fun
Said: 'Tell me, which leg comes after which'
This raised the centipede's mind to such a pitch
She lay distracted in a ditch
Considering how to run."

The point is that excessive attention to mechanics and technique focuses the speaker's attention on the wrong factors. The speaker should be concerned with these items, in this order of importance:

1. **The audience,**
2. **Ideas the speaker is most anxious to transmit to his audience,**
3. **Awareness of the importance of adequate vocal volume and force,**
4. **Desirability of "sparkle" and the release of the speaker's personality.**

A speech is essentially an IDEA, with the speaker's PERSONALITY wrapped around it. It is impossible to separate what a man SAYS from what he IS. **If the speaker's remarks spring from deep belief, and if he knows what he is talking about, it is impossible for him to give a poor speech.**

Without facts or belief you can't convince

NOW — LET'S GET READY

You have been assigned the task of giving a speech before your civic club, a staff meeting, your church group. Your first task is to select a subject. You should select a subject which:

1. *You know more about than your audience.*
2. *Your audience needs to know about.*
3. *Can be adequately developed in the time allotted.*
4. *Is appropriate to the educational and interest level of your audience.*
5. *Is capable of being developed with some fresh, new overtones and treatment which will cause you to be regarded as an appealing and original speaker.*

Having selected your subject it next is necessary to plan the route you intend to follow. The first step is to select a story, an impressive statement, or a quotation, which, because of its impact, will cause the audience to WANT to hear what you are going to say in the body of your talk. This story, statement, or quotation should be used as the first sentence of your speech.

The next step is to tell your audience why THEY should be interested in and listen to what you have to say about the subject. Audiences usually don't care what a speaker is interested in. They want to hear talk about the things

Your interest in your audience places your audience in the palm of your hand

THEY are interested in. The speaker must demonstrate to them that his subject affects their interests. If this connective link to the audience is built by the speaker as the second step of his speech, the audience will respond with their attention.

You should be fortified with sufficient proof, quotations, statistical data, citations of authorities and experts, etc., to prove to the audience that your position on the subject has a foundation in fact. Generalized assertions are not as compelling as factual data.

Finally the speaker should tell his audience what action they should take. The end of a speech, like the end of a sword, should have a point. Too many speeches end with a floundering repetition of statements made earlier in the talk. It is appropriate to summarize in a conclusion, but no summary is sufficient if it does not point the audience's attention toward a course of action. An audience respects a speaker who issues a call for action, even if the audience does not agree with the character of the action requested. Never end your speech without answering the question, "Where do we go from here?"

Not a speaker in the group

ODDS AND ENDS

1. *Don't memorize your talks.* Remember, the speaker's personality must "show through." In fact, the impact of speaker's personality determines the impact of his thoughts on the audience. Don't hide your personality behind stilted, memorized phrases. Rather, allow your usual conversational vocabulary to be the vehicle for expressing your thoughts.

2. *Don't apologize.* If you tell your audience you are a poor speaker, they will accept your opinion. If you DON'T tell them you are a poor speaker, they will at least be prepared to give you a chance to demonstrate that you are a competent speaker. Never apologize for insufficient preparation. There is no excuse for a speaker taking the time of an audience, without having prepared himself to occupy that time profitably.

3. *Give the impression of being a vigorous,* self-assured, wide-awake, agressive, and sincere person. An audience wants to listen to a MAN, not to a shilly-shallying self-doubter. You will be amazed at the amount of allegiance an audience will give you simply by your manifesting the characteristics of self-assurance, poise, and self-confidence. At the same time the speaker must feel, and give expression to, an appropriate degree of humility — and, after all, it is humbling to be given the honor of leading a group of people in that process of collective reflective thought which is called speaking.

A manager achieves his results through people. A speaker achieves his results through people.

A manager must be able to plan and organize. A speaker must be able to plan and organize.

A manager must lead. A speaker must lead.

A manager must be able to motivate and inspire people to action. A speaker must be able to motivate and inspire people to action.

A manager must make himself understood. A speaker must make himself understood.

A manager must have a purpose and the WILL to make others reach that purpose. A speaker must have a purpose and the WILL to make others reach that purpose.

The skills of the manager and the speaker are identical. The proportion of skills used varies only in response to the task at hand.

Civilization has been called "the victory of persuasion over force." The speaker is the bearer of the art of persuasion. He is the integrator of the ideas and the initiator of group action. His skills are not only those of the successful MANAGER, but those of the successful MAN.

Is It Evident That . . .

1. . . . the effective use of written and spoken language is a primary tool of the manager?

2. . . . we are judged by our associates and superiors partially by our abilities as a communicator?

3. . . . giving a speech is really simple if (a) you have something to say, and (b) you believe in the truth and importance of what you have to say?

4. . . . the most important thing in speaking is the audience?

5. . . . the formula for giving a speech is simple . . . and will produce results because it is based — not on abstract principles of rhetoric — but on the needs of the audience?

6. . . . that a manager can sell himself, can achieve a greater degree of success, through improving his capacities for leading through speaking?

Both vacancies will be filled by one man

"When in Doubt, Read On!"

[1]*Claude M. Wise, James H. McBurney, Louis A. Mallory, Charles R. Strother, and William J. Temple, "Foundations of Speech," Prentice-Hall, Inc., 1941.*

[2]*Elizabeth G. Andersch and Louis C. Staats, "Speech for Everyday Use," Rinehard and Company, 1950.*

[3]*Alan H. Monroe, "Principles and Types of Speech," Scott, Foresman and Company, 1949.*

[4]*E. C. Buehler, "You and Your Speeches," Allen Press, 1949.*

[5]*S. I. Hayakawa, "Language in Thought and Action," Harcourt, Brace and Company, 1940.*

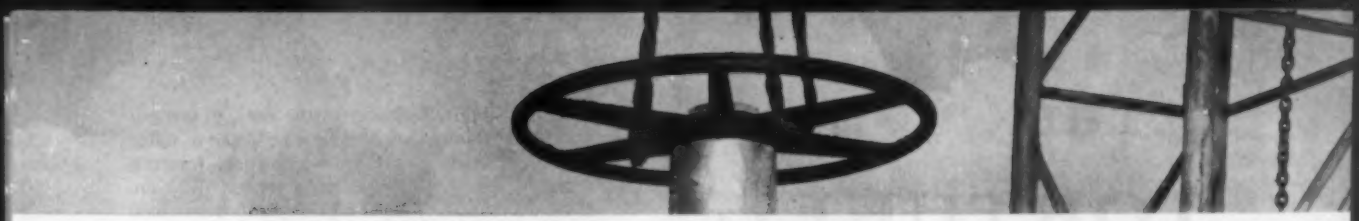
[6]*David Guy Powers, "Fundamentals of Speech," McGraw-Hill Book Company, Inc., 1951.*

[7]*Alfred Tack, "How to Overcome Nervous Tension and Speak Well in Public," T. S. Denison & Company, 1955.*

[8]*Alfred D. Huston and Robert A. Sandberg, "Everyday Business Speech," Prentice-Hall, Inc., 1943.*

[9]*Lester Thonssen and Howard Gilkinson, "Basic Training in Speech," D. C. Heath and Company, 1947.*

[10]*Lew Sarett and William Trufant Foster, "Basic Principles of Speech," Houghton Mifflin Company, 1946.*



"On-the-line overhaul saves time, saves money"

W-K-M Leverlock® Gate Valves feature through-conduit gate construction, parallel expanding gates, exclusive gate centralizers, controlled force seating, pressure seal bonnets, super-finished stems, seating surfaces sealed from the lading flow.

Pressure Ratings: ASA 300 through ASA 1500 pounds.

W-K-M® ASA Gate Valves

These valves can be overhauled fast and easy. No other valves give you the same long-lasting service and economy. No other valves require so little maintenance, yet provide such outstanding efficiency and performance.

Next time — and every time — specify W-K-M! *Available at leading supply stores everywhere* (from 2″ through 12″). Sizes through 34″ available on special order.

PRODUCT OF W-K-M's *Creative Engineering*

WRITE FOR CATALOG 300

W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

5913-R

THE TORTURED GENIUS

Who Invented the Diesel

Jim Moore

WHEN the channel steamer *Dresden* docked at London on the morning of September 30, 1913, shipping officials found themselves facing one of the strangest mysteries in the history of channel navigation. A passenger—the famed German inventor Rudolf Diesel—had disappeared from the ship, and with him many valuable papers.

In the 45 years since his disappearance the theories seriously advanced about his fate have covered almost every conceivable possibility. Accidental drowning could never be ruled out completely, and yet there were motives for murder and for suicide. On the other hand, it was never proven beyond doubt that Diesel died at that time; one newspaper report said he left the ship in disguise and went to Canada.

Regardless of how he met his end, Diesel's work lives on today as probably the greatest contribution to engineering and industry since that of James Watt.

His legacy—the diesel engine—is the most efficient internal combustion engine ever built. The full significance of his invention was not realized at the time of his death, but today Diesel would find the world has paid him the supreme tribute—by making his name a part of the language.

The fate of his engine contrasted greatly with the tragic, harassed life—and the mysterious death—of the man himself. Afflicted by excruciating headaches, challenged by his colleagues at every turn, and sensitive to the opposition and abuse he faced, Diesel proved that in spite of all obstacles he was the exemplar of what he believed an inventor should be.

"The inventor," he once said, "must be an optimist, since the full driving power of an idea is to be found only in the mind of the originator. He alone has the sacred fire to push it through."

That Diesel possessed this "sacred fire" was certainly evident even in his youth. Born and raised in Paris of German parents and educated for a time in London and later in Germany, he was fluently tri-lingual. At the engineering school he attended in Augsburg, Germany, he graduated at the age of 12—the youngest in the class—with the highest scholastic record in the history of the school.

At the same time he was a person of such sensitivity as to make his life almost unbearable. (Diesel, who thought of himself as a Frenchman, wrote in later years that his expulsion from France, with all other Germans, at the outbreak of the Franco-Prussian War left his mind permanently scarred with the humiliation of being a refugee.) In his youth his sensitivity drove him within himself and he became deeply absorbed in engineering studies. As a result, he won a scholarship to attend the Munich Polytechnic School.

At that time the most famous member of the faculty at Munich was Professor Carl von Linde, the engineer who first succeeded in liquefying air and who discovered many of the refrigeration principles employed today. By Diesel's own account, a statement by von Linde gave birth to the idea that determined the student's life work.

"Gentlemen," von Linde told his students at the end of a lecture, "we must conclude that, considering the great amount of fuel required, existing prime movers produce relatively small power." At that moment 21-year-old Diesel made up his mind to design a more efficient engine.

After graduation he went to Paris for von Linde, where he built and supervised a plant to produce freezing machinery. There, for a decade, he drove himself almost to the limit of his endurance. At that time he began to suffer acute headaches which were forerunners of a much more serious affliction. Diesel fought off the pain and worked on, learning more about compressors and their problems than he could have learned anywhere else.

While he continued to work for von Linde, Diesel devoted his own spare time to designing a new kind of engine. The internal combustion engine that was then moving to the fore in Germany appears to have been the basis of the new principles being formed in Diesel's mind. At last, in 1892, two years after he left Paris to handle von Linde's business in northern Germany, Diesel's first blueprints were complete, and he applied for a patent. From the German Patent Office came patent No. 67207—for "Working Processes for Internal Combustion Engine." Although the office had received many applications for such patents, the officials decided that Diesel's idea was brand new.

Actually, it was both old and new. From the internal combustion engines then coming into prominence in Germany, he borrowed the idea of turning the heat of fuel into useful work within a cylinder. But here the similiarity ended. Instead of having a spark explode compressed gases in the cylinder, Diesel employed a principle he had learned in his years of research: If air is compressed sufficiently, it will reach a temperature high enough to ignite fuel. Diesel found that at 500 lb pressure per square inch, the compressed air would reach a temperature of 1000 degrees Fahrenheit.

By devising a way of igniting fuel without a spark. Diesel did away with any need for a carburetor, which mixes gasoline and air into a vapor before it is injected into the cylinder. It was an important simplification because even in today's automobile engine the carburetor remains one of the most finicky parts. More important, his engine was designed to operate at a compression ratio more than double that of the gasoline engine. Thus, by finding a way of making a greater proportion of the heat in the cylinder do useful work, Diesel had done what he set out to do: He had designed a more efficient engine than any then in existence.

But the diesel engine was still nothing but a set of blueprints, and Diesel's first efforts to get it built at the Augsburg Machine Works met with skepticism. Accordingly, Diesel set out to prove his point, and in 1893 published the historic "Theory and Construction of a Rational Heat Engine to Replace Steam and the Existing Internal Combustion Engine."

His book did the trick. With Augs-

Jim Moore is a graduate of University of Toronto (BA), Ottawa University (MA) and Sorbonne (PhD). Now a writer on the public relations staff of Imperial Oil Ltd., he began his career as a newspaper man in Paris, France, and later worked on newspapers in Quebec City and Toronto. This article is reprinted from the Imperial Oil Review, publication of Imperial Oil Company, Ltd.

burg officials and the giant Krupp corporation sharing the risk, Diesel got the money to go ahead on construction. Within the year the prototype of Diesel's engine was ready for its first test. August 13,1893, Diesel stepped up to the machine and pulled a lever. The engine blew up, knocking him unconscious. As he convalesced in hospital his optimism returned. His notes, in fact, show that the explosion itself was a curious source of delight to him.

"I knew then just what I wanted to know," he wrote. "It was proven possible to compress pure air so highly that the fuel injected into it ignited."

Modifications followed. An improved fuel injection unit went into the engine, along with stronger cylinders and more accurately regulated valves. Because so few engineers could grasp the significance of Diesel's complex efficiency curves, tables, charts and formulas, he did most of the work himself, and supervised the rebuilding of the engine. At last, at Augsburg, in 1897, he unveiled his new machine. This time it worked perfectly. Soon businessmen and engineers were coming from all parts of the world to examine the new invention. Their enthusiasm was almost boundless as they quickly realized that with the heat generated from compression, a heavy oil—cheaper than gasoline—could be used to fuel the engine. Its economies were highly attractive.

Attractive, too, were the offers made to Diesel. The Krupp and Augsburg companies had paid the equivalent of $7500 for his construction of the engine. But in 1898, only a year after the completion of the first fully successful engine, the American brewing magnate, Adolphus Busch, paid Diesel $250,000 for the American and British patents.

Despite his newly won wealth, Diesel had more problems than ever. Inventors in several countries, notably in Europe, tried to infringe on his patents, while others criticized the engine as unsafe and uneconomic. In the factories, workers agitated against it, fearing its greater efficiency would cost some of them their jobs.

To defend himself and his engine against these attacks, Diesel traveled to many parts of the industrialized world, making speeches, writing articles and warding off threats of litigation. To some extent these trips were successful, but with his dignified bearing (which seemed pompous to many) and the pince-nez through which he peered at the world (disdainfully, some thought), he never cut a popular figure anywhere.

Moreover, unlike most of the great inventors of his time, Diesel was not a workshop engineer. He did not invent by rule-of-thumb or trial and error. His critics called him a "paper inventor" because every step he took was prefaced by meticulous mathematical analysis. He was, in short, an early-day "egghead."

Finally the strain of the struggle was too much for him. In 1898, at the age of 40 he suffered a nervous breakdown.

Comforted by his wife Martha, he gradually recovered enough to resume work, but his trips became less frequent, his experiments fewer and his defense of his engine less impassioned. He was never quite the same again. His headaches began returning with greater frequency and violence.

Then his investments failed. By 1913 he was all but penniless.

In that year, however, he saw a glimmer of new hope. The British government invited him over to talk to a group of manufacturers about using his engine in submarines.

He left his home in Augsburg, Germany, and on the night of September 29 boarded the channel steamer *Dresden* at Antwerp, Belgium. With him he carried the technical papers he was to show to the British manufacturers.

Apparently he was elated over his prospects in Britain, for those who saw him begin the trip said later that he looked well and acted as though he felt better then than at any other time in recent years. Once aboard, he said goodnight to his two traveling companions, went into his cabin and shut the door. He was never seen again.

When the *Dresden* docked at London the next morning, his cabin was empty and his bed had not been slept in. There was no evidence of foul play, but neither was there a sign of the highly important papers he was carrying.

Every part of the ship was searched and passengers and crew were questioned closely, but to no avail. For weeks after that his fate was a popular subject of speculation in the press. Gradually news of the impending war in Europe pushed the tragedy of Rudolf Diesel out of the news columns.

In 1917, curiosity was revived in Britain by a captured crew man from a German submarine. The German swore that Diesel had been pushed overboard because he knew too much about Germany's new submarines that would have been of service to the British. The sailor pointed out that only a few weeks after Diesel's disappearance, a body had been recovered from the Scheldt Estuary. Such a body had been found, and had in fact been identified as Diesel's but the identification had been based only on the size of the body and the presence on it of a pair of gold-rimmed glasses.

Because all the evidence is circumstantial, we will probably never know how Rudolf Diesel died. We do know, however, that he made an enormous contribution to industry and transportation. Within a few brief years of his death, millions were moving and living by his machine—the engine that, in one way or another, may have been responsible for ending the life of its inventor.

★ ★ ★

H&L Teeth that really dig!

and a combination that accelerates every trenching operation

there's no substitute for

FORGED HIGH ALLOY STEEL

BULLDOZER CORNER ADAPTER

Fits existing end bit holes—quick change flexpin type point maintains sharp corners—eliminates side draft, allows precision cuts —Blade loads easily in hardest material.

CRIMPON TYPE POINTS

Stay sharp—last longer—give more ditch per hour under all digging conditions. H&L has a point for every excavating and digging condition.

Crimpon type
Pat. No. 2807105

H&L TOOTH COMPANY

1540 SOUTH GREENWOOD AVENUE MONTEBELLO, CALIFORNIA

Performance makes the world of difference

POWELL Lubricated Plug VALVES

Fig. 2201—Flanged End, semi-steel Lubricated Plug Valve for 175 W.O.G. Single gland type. Wrench operated.

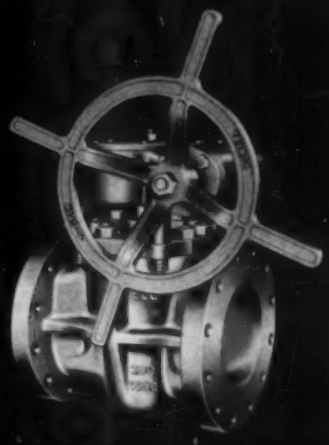


Fig. 2207G—Flanged End, semi-steel Lubricated Plug Valve for 200 W.O.G. Bolted Gland type. Worm gear operated.

Fig. 3058—Screwed End, carbon steel Lubricated Plug Valve, ASA 300 pound. Screwed gland type, wrench operated.

Powell . . . world's largest family of valves

Powell Lubricated Plug Valves—a triumph of valve design and engineering—are preferred to control the flow of fluids in petroleum refineries, petro-chemical plants and oil storage facilities all over the world.

Note these Powell features: simple design (only three basic parts—body, bonnet, plug); fast opening and closing; straight streamline flow through when fully open; tapered plug for positive seating; carefully machined surfaces of plug and body are unexposed to and protected against the action of the fluid being handled when valve is open.

These valves are available in sizes from ½" through 16"; semi-steel, carbon steel, and, on special order, in other alloys. Consult your nearest Powell valve distributor, or write to us for the facts and illustrated literature.

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

PROTECTION *is our business*

Through complete Quality Control — Nicolet Asbestos Pipe Line Felts have received universal acceptance for their uniformity and absolute dependability.

Whether your pipe line requirements demand Nicolet Asbestos #15 "Standard", #8 "Tufbestos" or #10 "Reflecto" (the new, improved, white Asbestos Felt) you are assured of getting the best protection obtainable.

And now—the addition of "Old Nic" Glass Wrap to this family of Pipe Wrap products makes Nicolet your best source for complete pipe line protection.

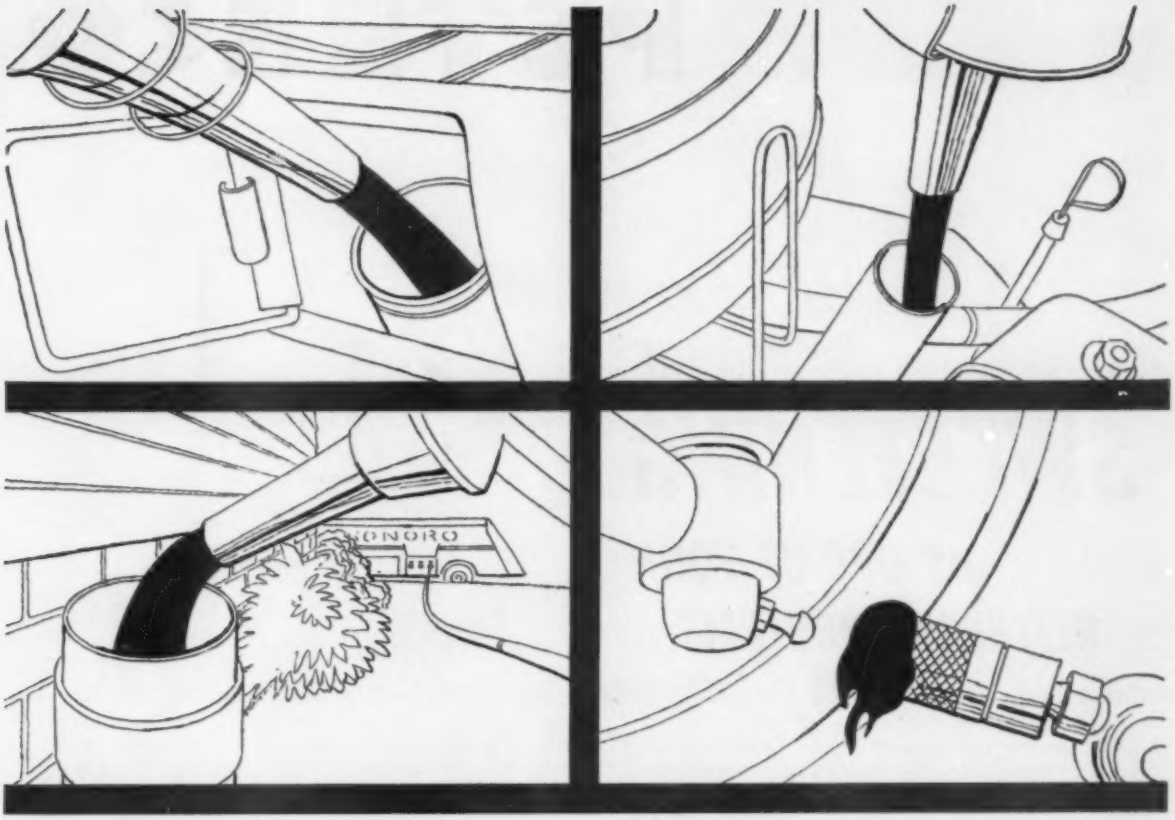
"Old Nic" has uniform porosity which allows hot tar or asphalt enamel to bleed through, while letting hot gas escape, minimizing "holidays". "Old Nic" Glass Wrap will most effectively protect yard wrapped pipe against impact damage. It is equally effective in over-the-ditch operations.

Write today for full specifications and samples of Nicolet pipe protecting products.

Distributed throughout the United States • District Sales Offices: Ford & Washington Streets, Norristown, Pa.; P.O. Box 777, Hamilton, Ohio

NICOLET INDUSTRIES, INC.

FLORHAM PARK, NEW JERSEY



RAINBOW FOR SALE... with new finer-flaked Du Pont dyes

Du Pont petroleum dyes provide sales appeal for your products more efficiently than ever before

Because flaked dyes are virtually dust-free, they are constantly gaining in popularity. Today they're becoming the standard material for dyeing gasoline as well as adding sales appeal to other petroleum products—kerosine, home-heating oils, tractor and diesel fuels, lubricating oils and greases.

Now . . . faster dissolving. The new finer-flaked Du Pont dyes now dissolve more rapidly than ever. As a result, more and more refiners are finding they can take advantage of the dust-free properties of Du Pont flaked dyes.

Lower handling costs. The new flaked form of Du Pont petroleum dyes makes them free-flowing and easier to handle than powders. They are more compact, take up approximately half the space of conventional powdered dyes. Drum height has been reduced to 22 inches. This, too, makes handling easier and faster, as well as saving valuable storage space for the refiner.

Many colors. You can get these finer-flaked Du Pont dyes in orange, red and bronze. (Blue dye is available in a crystalline form which has the same advantages as flaked dyes.) Samples and full details are available from your Du Pont Petroleum Chemicals representative. Or write to E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

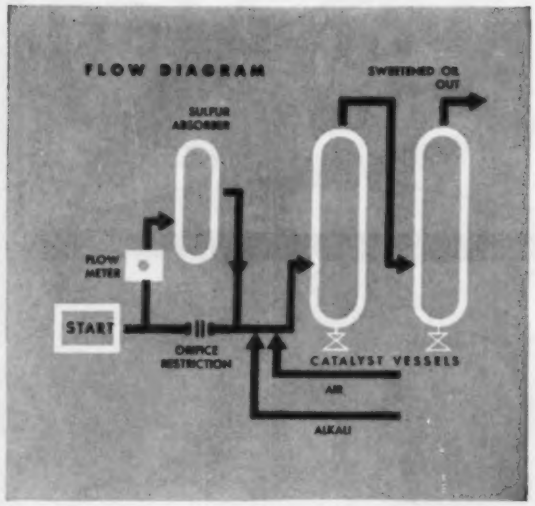
DU PONT

Better Things for Better Living . . . through Chemistry

Tetraethyl Lead and other Petroleum Additives

PRODUCT IMPROVEMENT WITH

PETRECO



IF SWEETENING IS ONE OF YOUR REFINERY PROBLEMS...

these facts about PETRECO* BENDER Catalytic Sweetening† may show you the answer:

LOW OPERATING COSTS: The average treating costs of Petreco Bender treating units are about 0.5 cents per barrel. Copper chloride or doctor treating costs, exclusive of amortization, generally exceed 1.0 cents per barrel. *The value of the volume loss in doctor treating alone often exceeds the total operation and amortization costs of Petreco Bender catalytic sweetening.*

SWEET NON-CORROSIVE PRODUCT: As compared to doctor treating, less sulfur is used, resulting in the delivery of a consistently non-corrosive product. *The use of less sulfur also lessens octane loss.*

ELIMINATES AIR AND WATER POLLUTION: Processing is in a closed system, eliminating air pollution and the attendant safety hazards. This eliminates open batch type agitators, thereby assisting in safety programs. *There is no "black strap" carry-over or carry-under to contaminate waste disposal systems.*

The product from the Petreco Bender unit is low in trace metal ions. Where a water wash is required to meet local product specifications, emulsion problems are not encountered due to the cleanliness of the Bender treated oil.

The only spent alkali withdrawn from the Bender unit each day is the small amount not consumed in the process.

HIGH YIELD: There is no volume loss in the system other than sampling and spillage. The volume loss in other sweetening processes is the greatest expense factor.

CONTINUOUS REGENERATION NOT NECESSARY: The catalyst retains its activity for long periods of time. This is made possible by the continuous addition of small quantities of air and alkali. Catalyst life without reactivation is usually two years or more. *Two Petreco Bender plants have been operating for over three years without any reactivation of the original catalyst.*

LOW INSTALLATION COST: *Unit cost for new equipment is comparatively low, ranging from $15 to $30 per barrel of daily throughput capacity.* If existing vessels are available and appropriate for conversion, this cost can be substantially reduced. Very often the charge may be taken directly from a distillation unit with existing pumps, exchangers and instrumentation, reducing the installation cost further.

SMALL TREATING AREA REQUIRED: Where ground areas are congested, the area occupied by any treating unit is of great importance. The plot dimensions for a 5,000 bpd Petreco Bender unit, for example, would be approximately 20′ x 35′.

*PETRECO *is a registered trademark of Petrolite Corporation.*

† *For middle range distillate streams such as kerosine, stove oil, light gas oil, No. 2 fuel oil, coker naphtha and catalytic gasoline.*

B-60-2

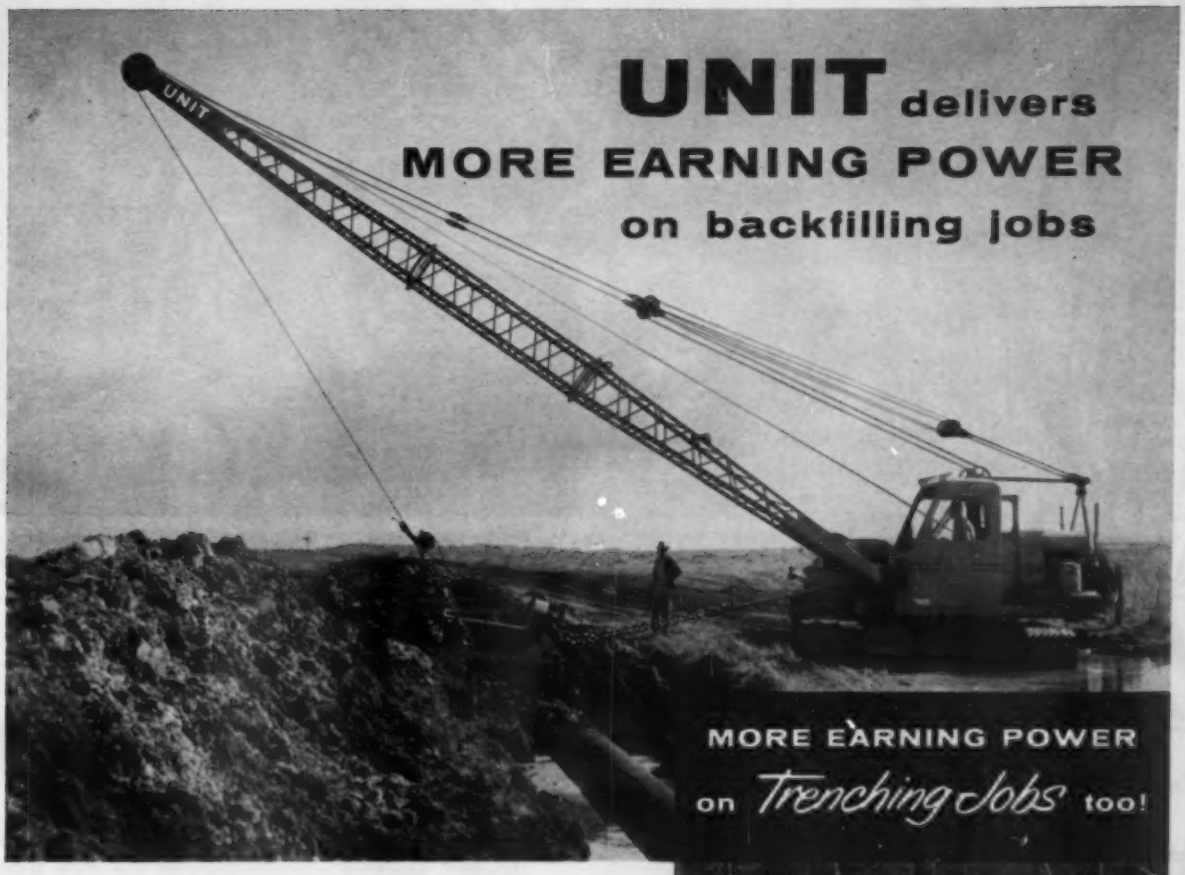
PETROLITE CORPORATION

CANADA: Petreco, 4528 Stanley Drive, Calgary, Alberta
COLOMBIA: South American Petrolite Corporation, Bogota
ENGLAND: Petrolite Limited, 20 Savile Row, London W.1
GERMANY: Petrolite Anlagenbau und Vertriebsgesellschaft m.b.H., Frankfurt a. M.
VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

REPRESENTATIVES

ARGENTINA: S. A. ASTAR, Buenos Aires
BRAZIL: WERCO, Ltda., Rio de Janeiro
ITALY: NYMCO, S.p.A., 9 Lungotevere A. da Brescia, Rome
JAPAN: Chiyoda Chemical Engineering and Construction Company, Ltd., Tokyo
KUWAIT: F. N. Dahdah, Box 1713, Al Kuwait
MEXICO: R. E. Power, Sierra de Mijes No. 125, Mexico, D. F.
NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
TRINIDAD: Neal and Massy, Ltd., P. O. Box 544, Port of Spain

PETRECO DIVISION
3202 South Wayside Drive (P.O. Box 2546), Houston 1, Texas
1390 East Burnett Street (P.O. Box 7216), Long Beach 7, California



UNIT excavators are big producers on any pipeline job, from digging trench, stringing and lowering-in pipe to backfilling. They are fast operating on the job . . . extremely mobile . . . travel any terrain . . . convert to all attachments for greater versatility . . . and their unmatched dependability assures continuous on-the-job output under the most adverse conditions.

UNIT design and engineering give you many advanced features that assure more output . . . more earning power. You get a one-piece cast main machinery case with all gears, shafts and bearings completely enclosed running in a constant bath of lubricant; you get straight-in-line engine, torque converter, worm drive direct to main machinery; all modern efficient disc type operating clutches; automatic traction brakes, and dozens of other advanced features not found even on the highest priced machines.

You can bid jobs lower, complete them faster and more profitably with the EARNING POWER of a UNIT on your job. See your UNIT dealer today or return the coupon for more information.

UNIT

UNIT CRANE & SHOVEL CORP.

6603 W. Burnham Street
Milwaukee 19, Wisconsin

UNIT crawler excavators are quickly and easily converted to trench-hoes. Provide the reach, depth and speed for more profitable operation.

UNIT CRANE & SHOVEL CORP.
6603 W. Burnham Street, Milwaukee 19, Wisconsin

Please send complete information on
☐ Trench-Hoes ☐ Draglines

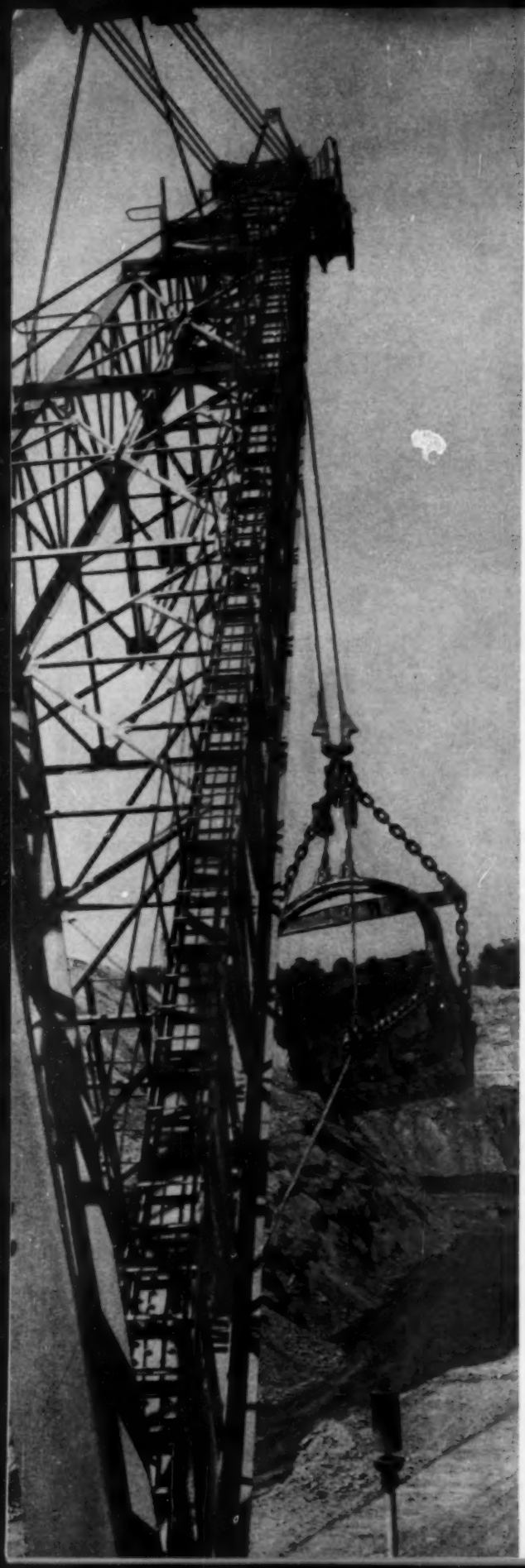
Name _____

Title _____

Company _____

Address _____

City _____ Zone _____ State _____



Drilling for oil—USS Tiger Brand Rotary Drilling Lines on one of the world's deepest wells—combine strength, toughness and long service life.

From the Tiger's mouth—

How to get

Regardless of the type of equipment you operate or the size, grade or construction of the wire rope you use—when you get better service from that wire rope you save money.

Proper selection and care of your wire rope will pay off in longer rope life and consequent operating economy. Here are 10 ways to increase the life of wire rope:

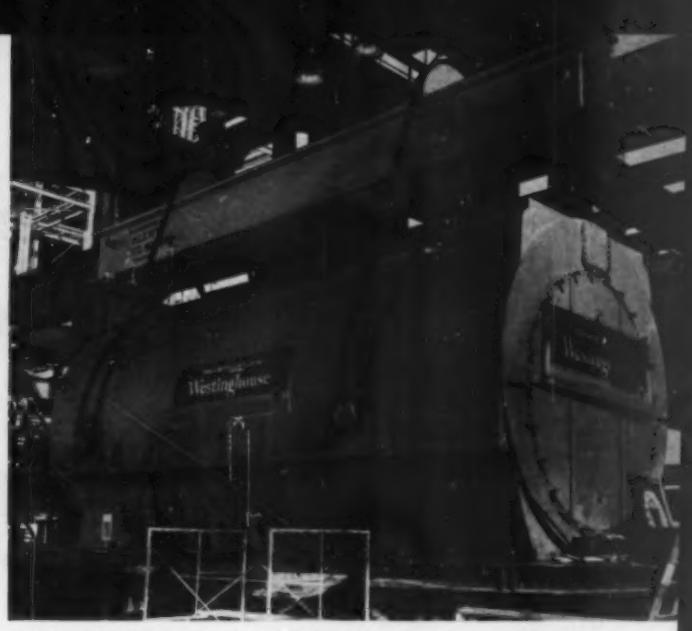
1. Get the right rope. Carefully examine the operating requirements for your rope, determine how heavy the loads will be, how much abrasive wear, distortion, or crushing the rope must withstand, and how flexible it must be. Then choose the USS Tiger Brand Wire Rope that has the properties you need . . . there is one for every type of job.

2. Unreeling. To prevent kinking, be sure the reel or coil is free to rotate as the rope unwinds. Mount reels on an unreeling stand or on a shaft supported by two jacks. Otherwise, hold the rope end and roll the reel along the ground to unwind the rope. Always use this latter method for coils.

3. Sheaves and drums. Align all sheaves. Be sure that sheaves and drums are free to rotate and large enough in diameter to prevent sharp bending. Grooves must be slightly larger than the rope diameter and, if scored or badly worn, should be reground before new ropes are installed. Sheaves with broken flanges should be replaced immediately.

Strip mining—USS Tiger Brand Hoist Rope for strength with flexibility, Tiger Brand Drag Lines for strength with abrasion resistance, and Tiger Brand Boom Supports for high resistance to vibration fatigue.

Building a super highway—USS Tiger Brand Shovel Rope, Dozer Rope and Scraper Rope give longer service with less down time.



Lifting industrial loads—USS Tiger Brand Slings lift the heavy loads safely. Crane hoist ropes provide strength and flexibility.

more service from your wire rope

4. Wire rope fittings. Install sockets, clips, swaged fittings or spliced loops or thimbles depending upon service requirements. Tiger Wire Rope Sockets, properly attached with molten zinc, develop the full strength of the wire rope.

5. Seizings. To prevent untwisting, apply seizings to the ends of any non-preformed wire rope that is not attached to permanent fittings. When you cut a non-preformed wire rope, apply seizings on both sides of the cut to prevent distortion.

6. Lubrication. Lubricate your ropes regularly with Tiger Lube Wire Rope Lubricant to cut down internal wear and reduce corrosion.

7. Cutting back. It is often advisable to change the position of a rope on sheaves and drums by cutting short lengths of rope from the drum end. This distributes wear more evenly, prevents fatigue from concentrating at any one section of the rope, and increases rope life. If you plan to cut back, order your ropes a little longer than normally required.

8. Reverse ends. Reversing a rope, end for end, will increase its life if half of it gets most of the wear. Reversing distributes wear and fatigue evenly throughout the rope.

9. Storing wire ropes. If you take a rope out of service for any length of time, clean and lubricate it thoroughly. Then store it in a dry place, protected from the weather.

10. When in doubt. If you need help in selecting the right rope or in setting up good maintenance procedures, call in a Tiger Brand Wire Rope Engineer. He can give you expert advice on any wire rope problem. Just call our nearest distributor or send the coupon.

USS and Tiger Brand are registered trademarks

American Steel & Wire
Division of
United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad

American Steel & Wire, Dept. 6175
614 Superior Ave., N.W.
Cleveland 13, Ohio

Please send me a copy of your booklet, "Longer Life from your Wire Rope."

Name_____

Position_____

Company_____

Address_____

City_____ **Zone**_____ **State**_____

Effective Leadership Induces Creative Group Thinking

"Do it yourself projects" for determining employees' and supervisors' opinions, may be more economical than hiring a consulting firm . . . However, the company must be sincere, frank, and fair. Planning must be thorough, and the project conducted under able leadership.

Carl Mullins White

PROGRESSIVE COMPANIES want the benefit of the opinions of their supervisors and employees. Many of them devote a great deal of effort to gathering these opinions.

One way to ascertain what people are thinking is to call a cross section of them together in small groups and solicit comments on previously prepared questions. This need not be done by an outside consulting firm. Care, however, should be used in selecting the leader for such conferences. He must have the ability to elicit spontaneous expressions and the wisdom to recognize values in ideas.

Leadership may easily be the factor which determines whether genuine values are achieved or not. This leadership is based on a demonstrated honesty of purpose toward employees and the observance of such rules as the following:

1. Call into any one group employees of as nearly as practicable the same salary level. Certainly an employee should not be thrown in a conference with his supervisor or his department head.
2. Make conferees feel that their statements will be treated as confidential.
3. Make them feel that their opinions are wanted.
4. Make them feel at ease and encourage them to talk.
5. Have genuine questions to ask, based on real problems and situations.
6. Listen and respond to their thoughts and feelings.

The author, Carl M. White, training specialist, is interested in many phases of industrial training. He has a BS degree from Northwestern University, and MA degree in industrial psychology from the University of Tulsa, and has done graduate study at the University of Oxford, England. White has done extensive research in employee training practices in the petroleum industry. He is an educational advisor to the U. S. Air Force Reserve.

Plan It First

A meeting of this type requires considerable advance planning by a qualified leader with a genuine interest in the opinions and feelings of the conferees.

Studies have been conducted with the personnel of various oil companies to determine the effect of leadership on the thinking of the group.

One such experiment dealt with 20 participants in a supervisor training course. In this conference, a practical problem was presented, i.e., how to gain willing compliance with an important but unpopular safety regulation. The problem was based on an actual incident, but with names, places, and some minor details changed to obscure identities.

The leader could have simply explained the problem to the audience in his own words, but it was decided to have it acted out by two of the members. One took the part of a supervisor attempting to enforce the regulation and the other acted as the employee. Each of the "actors" had been told about his part two days ahead of time. The two had not conferred with each other.

Groups Evaluate Role-Playing

At the conclusion of the role playing, the conference divided into three groups: A, B and C. This division was done alphabetically, without reference to ability or personality. The conference leader selected chairmen for the groups. He did this on an informal basis, by asking the members to name any whom they considered skilled at leading discussions.

The conference leader asked all three groups to discuss what they saw in the role playing, how the "supervisor" dealt with the problem, how the "employee" responded, and how the supervisor's role should have been handled. The conference leader also asked each group to consider how to gain the most thorough compliance with the safety regulation within the best possible human relations situation. He requested each chairman to submit a list of the ideas developed by his group.

At this point, the three groups were almost perfectly balanced and equal. The variable was the instruction given to the group chairmen.

The conference leader asked the chairman of Group A to conduct his meeting in a commonplace manner. He was to be neither particularly critical, nor especially constructive, but to assume an ordinary, middleground, businesslike atmosphere.

The chairman of Group B was requested to take a hypercritical attitude toward every idea advanced. He was subtly to inject a cautious, almost cynical state of mind into the meeting. He was to suggest that the conferees should be prepared to defend any proposals made. Each conferee was to feel "on the spot."

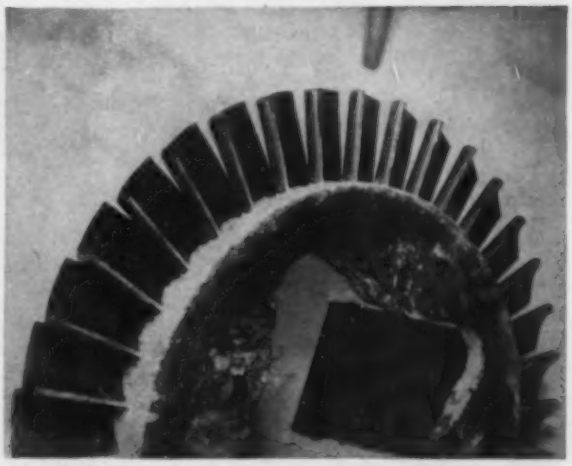
Instructions Vary

The conference leader asked the chairman of Group C to be unusually

NEW SHELL POWER RECOVERY PROCESS CUTS CRACKING COSTS

Shell now offers a way to run power recovery turbines on waste energy. The key to this process is a simple, effective fines separator that protects gas turbine blades to obtain long turbine life. Look at these unretouched photographs.

WITHOUT SHELL PROCESS – Turbine nozzle blades after only 650 hours of operation.



WITH SHELL PROCESS – After 4000 hours of operation.

The use of this Shell-designed fines separator with existing fluid-bed cat cracker regenerators permits the inexpensive expansion of carbon-burning capacity. In new systems it is capable of making substantial savings on your steam or power requirements. The process is licensed by Shell and through authorized contractors. Inquiries are invited. Shell Development Company, 50 West 50 Street, New York 20, New York.

SHELL DEVELOPMENT COMPANY

SHELL

FIG. 1. GROUP A MADE A LITTLE PROGRESS.

FIG. 2. GROUP B WAS AT A STANDSTILL.

permissive and to encourage his members to speak. He was to inspire confidence and a feeling of the importance of each man's thinking. In short, he was to preside in what is commonly known as a "brainstorming" session.

Each chairman conducted his group in the manner requested and submitted his report.

The results were startling.

Group A, the "middle group," performed about as could be expected. It produced three rather helpful suggestions (Fig. 1).

Group B, having rested on a high center of mutual criticism had produced no positive ideas at all (Fig. 2).

Group C had developed 10 excellent suggestions for improving the handling of the safety regulation (Fig. 3).

Why so much difference?

FIG. 3. C WAS A GO GROUP.

Results Vary More

Obviously the three groups of men were nearly equal in intelligence, personality traits, and experience, since they had been chosen at random from a group of fairly even ability. Yet one group accomplished many times as much as both the others. In fact, the differences between them were more profound than this mathematical comparison would indicate. An observer going from one meeting to another, could readily tell the difference. Group B was at a virtual standstill. Most of its members were hiding in the shell to which human beings retreat when they feel that their ideas may bring embarrassing lack of acceptance. Every man in Group C was thinking creatively and intently.

The difference was the magic of atmosphere.

Atmosphere is created by the skill of the leader, by his ability to recognize ideas and feelings and help people to build upon each other's efforts.

Employee Opinion Surveys

The same principles can be applied in drawing out the opinions of employees of all levels.

An able conference leader can call together a group of employees of a given level and ask them a series of questions about company activities.

The primary objective of such a meeting is to obtain answers to the specific questions asked. The value of the answers depends on the care exercised in devising the questions and on the skill of the conference leader.

Some secondary results are often more significant than the primary product. Such meetings sometimes disclose that the majority of supervisors do not communicate information about company activities clearly and fully. Employees feel that their supervisors either do not understand company policies and plans fully or are unable to explain them clearly.

These conferences may also open an upward channel which can be used again and again — through which valuable information will flow. However, it must be made clear that only summary reports are submitted to management. No individual employee's statements are disclosed.

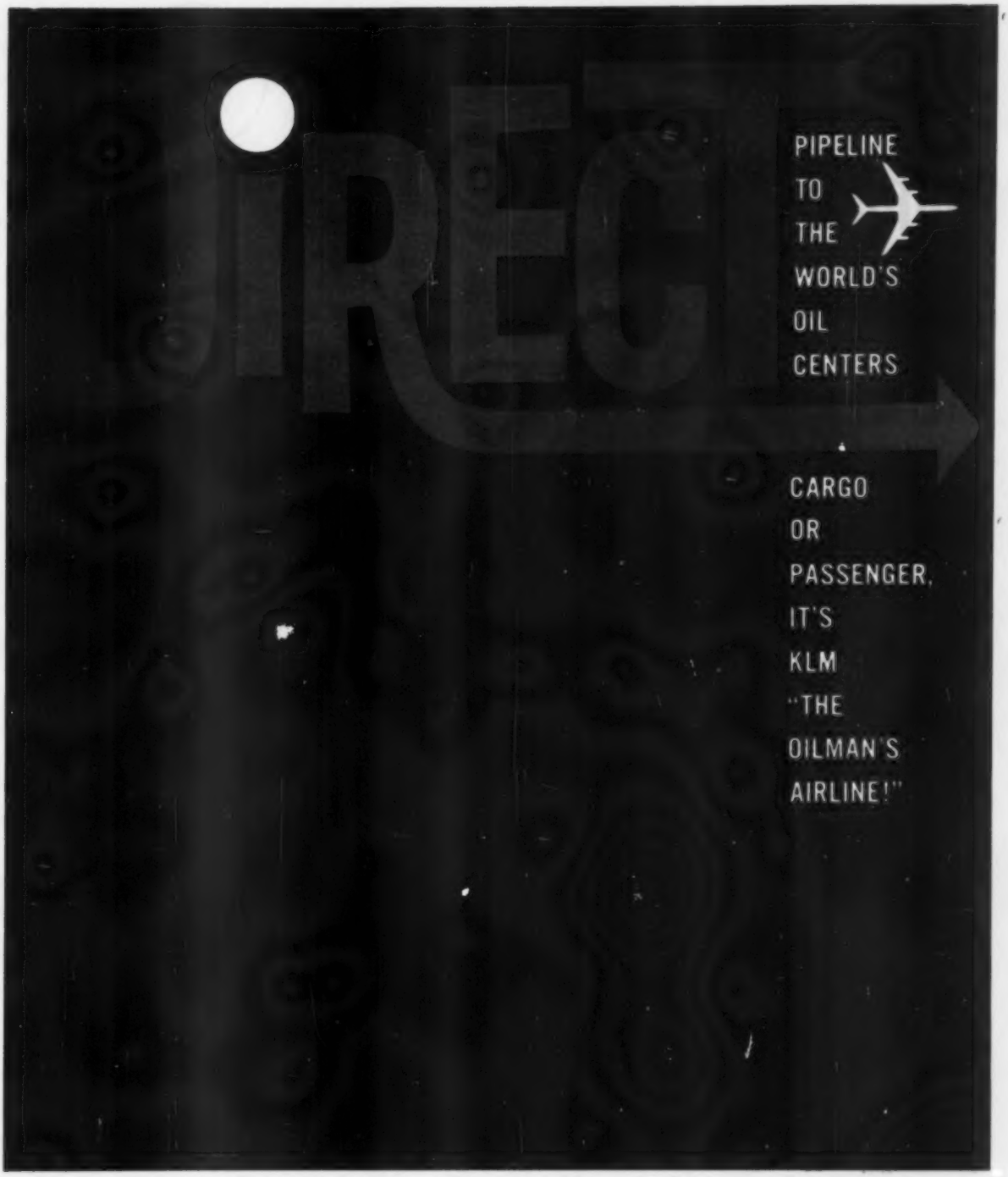
Employees can be induced to express their opinions. They will speak what is on their minds if the atmosphere is right, if their confidences are respected, and if action occasionally is taken on their recommendations.

Such meetings may also improve morale by giving employees a chance to talk.

So, whether in a supervisory conference or in an employee meeting, a critical item is leadership.

It is the task of the leader to create a permissive and challenging situation. His is the opportunity to make employees believe that their ideas are:

Welcome
Confidential
Important ★ ★ ★

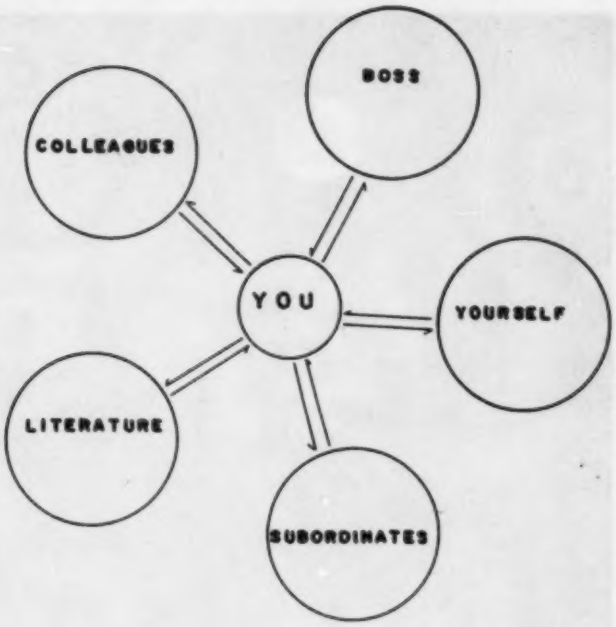


FROM HOUSTON: direct to Europe, Africa, the Near, Middle and Far East. **FROM MIAMI**: direct to South America. Daily service. **FROM MONTREAL**: direct to Europe, Africa, the Near, Middle and Far East. **FROM NEW YORK**: direct to all Europe and beyond; also to Curacao, Aruba and South America. **IMPORTANT**: Your cargo receives rapid ground handling. Awkward shapes easily accommodated. **FOR PASSENGER SERVICE**: Call your Travel Agent or KLM office. For cargo service: Contact your Cargo Agent, Forwarder or KLM office.

KLM ROYAL DUTCH AIRLINES • 609 FIFTH AVENUE • NEW YORK 17, N. Y.

THE WORLD OVER
KLM
ROYAL DUTCH AIRLINES
THE WORLD'S FIRST AIRLINE

10-Way Communications



Here's a formula for checking your own communications rating . . . and indicating how to get back in balance if you're stressing one factor at the expense of another

Thomas Garcia-Borras

THE NEED for better communications is exemplified in the following cases:

- Your boss tells you: "Our sales have increased tremendously." *What you probably understood was: "I'm going to get a raise."*
- The boss tells you: "I want to see you in my office." *You thought: "What did I do wrong?"*
- You ask your boss: "Why don't we organize the work in a different way?" *Boss thinks: "Who's this bird to tell me what we should do, anyway?"*

The list can be made almost endless. Fortunately there is a way to shorten or almost eliminate that list. The answer is *better communications.* Not only with your boss, but with everybody, including yourself. The following formula toward better communications is based on your "Ten-way communications," as a definite improvement over the old phrase "Two-way communications."

The Formula

From the illustration we see that in our job we communicate with:

- **BOSS (B).** *To inform him; progress reports, memos, etc.*
- **COLLEAGUES (C).** *To consult and inform them; seminars.*
- **SUBORDINATES (S).** *To train them; keep track of their work.*
- **LITERATURE (L).** *To keep up; to publish.*
- **OURSELVES (Y).** *Thinking; asking ourselves questions.*

No matter how you look at it, on any job your total communications are:

$$B + Y + C + L + S = 100\% \quad . \quad (1)$$

A study of this formula shows us that:

(a) No factor should be zero
(b) We should strive for an appropriate balance
(c) According to our own job requirements, the balance will shift temporarily, and temporarily only.

Formula at Work

A further study of the illustration and formula (1) shows that the following factors must approximately balance against each other:

(a) **Communications to boss and subordinates.** Because you should communicate with the boss as much as with your subordinates.

(b) **Communications to yourself against subordinates, colleagues and literature.** That is, your thoughts, ideas and questions should be discussed, checked and answered by your subordinates, colleagues and literature (you would not expect your boss to discuss, check and answer ALL your questions, would you?)

Therefore, formula (1) may take another form:

$$B + Y = S + L + C \quad . \quad (2)$$

So, 50 percent of your communications should be covered by your boss and yourself communications. The other half will be used in communicating with your subordinates, colleagues and literature. For instance, if most of your communicating time is spent with your boss, you automatically know that you are missing something. The formula tells that what you are missing is communications with subordinates, literature, colleages and even with yourself.

Rate Your Own Job

It took less than five minutes for a chemical engineer in a supervisory position to rate his job as shown in Table 1.

This engineer's rating indicated to him that he did too little communicating with his colleagues, a fact he **realized** only after rating himself.

Is There a "Right" Balance?

There is not an exactly "right" balance, but when one of the factors gets too small, we might be missing something. For instance, little communications with our colleagues may have as one of the consequences that no one knows that we exist. On the other hand, when a factor gets too large, we might be gaining on one factor at the expense of one or more of the others.

Different persons, and different jobs, will have different ratings. But what we should strive for is an **appropriate balance** of the five factors.

"A few answers to questions about

HIGH GASOLINE TAXES

all oilmen should know!"

Q. What is the average federal and state tax on ten gallons of gasoline?

A. About *one dollar!*

Q. At what rate, then, is gasoline taxed?

A. At about 50% of the price, or nearly five times the tax rate on such luxuries as furs and diamonds.

Q. How much have gasoline taxes increased in the last ten years?

A. About *51%*.

Q. What about gasoline prices in this same period?

A. They have increased only 5%, as compared with 22% for prices in general.

Gasoline's a buy... only the tax is high!

COMMITTEE ON PUBLIC AFFAIRS
of the American Petroleum Institute
1271 Avenue of the Americas, New York 20, New York.

Standing two stories tall, the vertical plate shot blast can clean plate ten feet wide and forty feet long

NEW AT BEAIRD

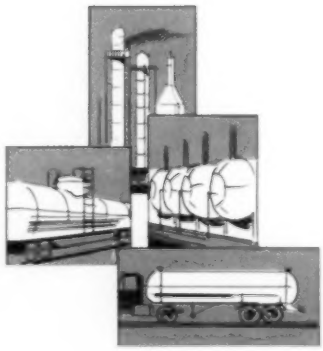
Assembly Line Vertical Plate Shot Blasting

Plate used in fabrication at Beaird is shot blasted cleaner than the proverbial whistle. Mill scale and foreign material are scoured off to provide a longer lasting paint bond, improve weld quality and free tank interiors from loose particles that may clog lines or contaminate product. Yet assembly line planning at Beaird has made this new service available without added cost to customers.

The vertical plate shot blasting system is just one of the many important equipment additions that are part of Beaird's planned facilities growth. Other new items include a 600-ton Gap Frame Press, 20-foot Plate Bending Rolls, Large Boom Welders, a 100-ton Bridge Type Crane and Precision Flame Planner for plate edge preparation.

Beaird is daily adding to its list of manufacturing accomplishments with such products as aluminum and alloy rail tank cars, stainless steel fractionating towers, giant pulp wood digesters and other specialized pressure vessels.

Check with Beaird on your next heavy steel or alloy product . . . you may save both time and money.



THE J. B. BEAIRD COMPANY, INC.
A subsidiary of American Machine & Foundry Company
Shreveport, Louisiana

SALES OFFICES: Shreveport, New Orleans, Louisiana • New York, New York • Tulsa, Oklahoma • Houston and Midland, Texas
BEAIRD INTERNATIONAL, INC., SHREVEPORT, LOUISIANA • Sales Offices: Calgary, Alberta, Canada • Caracas, Venezuela

another AMF BEAIRD product

Special Cases

1. **You have no subordinates.**
   To balance the equation, you will have to increase the L factor. This is clear, since having no subordinates you will have to get most of the information yourself. The C factor might increase also. The formula even applies to the janitor with the least seniority. Since he probably does little or no reading on how to do a better job, and has no subordinates, formula (2) is balanced by communicating mainly with his boss and colleagues (his colleagues will teach him the "tricks of the trade").
2. **You have no boss.**
   This is a rare case. Anyway, to balance the equation the Y factor should be increased. This is explained by your increased responsibilities and more decision-making activities. You will have to communicate more to yourself than if you had a boss.

Large Factors

If under normal working conditions one of the factors gets too large, the explanation might be:

1. **BOSS.**
   When this factor gets disproportionally large, it is because:
   (a) You depend too much on him
   (b) Eager-beavering?
2. **YOURSELF.**
   (a) "Delegate" your problems
   (b) Are you a dreamer?
   (c) Are you in the game?
3. **SUBORDINATES.**
   (a) Get off their backs
   (b) Maybe you are giving them information they no longer need or do not care about
4. **LITERATURE**
   You are not on the ball
5. **COLLEAGUES**
   (a) Too much dependence on others will show you are on the wrong job
   (b) Maybe you do not trust your subordinates and "go somewhere else to get information, "Neighbor's grass looks greener."

The Author

A NATIVE OF BARCELONA, *Spain, Thomas García-Borras has a degree in chemistry from University of Mexico in 1948 and he did post-graduate studies in chemical engineering at Rice Institute of Houston, Texas, in 1955. He had seven years experience in various phases of the Mexican chemical industry and since February 1956 he has been in the Research Department of Monsanto Chemical Company, Texas City, doing work in the research and development of linear polyolefin processes.*

García-Borras is a member of the American Chemical Society and prepares condensations for CHEMICAL ABSTRACTS *from English, Spanish, French, Italian, and Portuguese studies. He has written more than 20 technical papers.*

Small Factors

On the other hand, one of the factors may almost disappear, because:

1. **BOSS.**
   When it gets too small, it might be that
   (a) You do not trust him
   (b) Poor relations with your boss
2. **YOURSELF.**
   (a) No inquisitive mind; maybe you are just too lazy.
   (b) Lack of incentive to do a a better job.
3. **SUBORDINATES.**
   (a) You are withholding information that should be passed down the line.
   (b) You do not know what they are doing.
   (c) Poor relations with your subordinates.
4. **LITERATURE.**
   You do not catch up with the literature. You are being left behind.
5. **COLLEAGUES.**
   (a) Poor relations
   (b) Ignore what others are doing and how they can help you
   (c) You are a lost soul

TABLE 1.

	BOSS	HIMSELF	SUBORDINATES	COLLEAGUES	LITERATURE
	• Memos	• New ideas	• Explaining why's	• Talking	• Writing
	• Reports	• Making job easier	• Formal training	• Discussing	• Reading
	• Oral information	• Learning job	• Checking work		• Studying
% Communications:	15 - 20	20 - 25	25 - 30	5	30 - 35

Shift of Equilibrium

Temporary shifts on the equilibrium of the equation do occur from time to time, depending on the nature of the work, and one of the factors becomes more important at that particular time. For instance:

1. **BOSS.**
   When a major decision or a major organizational change has to be made, you will probably have to spend a great deal of your time with the boss.
2. **YOURSELF.**
   Picking up the best solution out of two or more probable solutions to a problem where a clear cut answer is not possible.
3. **SUBORDINATES.**
   (a) Checking on brand-new employees
   (b) Too much at stake if your subordinates miss the run.
4. **LITERATURE.**
   Typical literature surveys
5. **COLLEAGUES.**
   You have a problem that requires the presence of a specialist. The above list of possible explanations of why a factor may outgrow the others or may disappear from the equation, is by no means exhausted. But, applying and studying the formula will show you where and why you are missing.

Conclusions

As usual, we sometimes do not know what we are doing wrong until somebody tells us and get embarrassed. The "Ten-way communications" formula tells us where we are missing. A balance of the five factors in the formula is needed to take full advantage of all of them.The formula helps us discover whether we are paying too much or too little attention to one of the factors.

The balance in equation (2) may temporarily shift to meet specific situations, but should return to its equilibrium as soon as the particular problem is solved.

Better communications can be obtained only through better use of our "Ten-way communications" formula. Let us illustrate this point: "A man on Mars will not communicate with us unless we receive and understand his message. It is immaterial how good his **instruments** are and **how many** messages he sends us. He still does not communicate unless we understand his message." ★ ★ ★

NAYLOR..

the Line Pipe Structure for Gas-Gathering Service

NAYLOR's exclusive lock-seamed-spiralwelded structure makes this the pipe that's built for gas-gathering service.

Light weight assures easy handling and installation. The lockseamed-spiral provides extra strength against collapse and extra safety against shock loads, stresses and strains. That's why you can depend on it—right down the line.

NAYLOR pipe comes in diameters from 4" to 30" and in a range of wall thicknesses. Pipe ends of standard weight thickness are available for field welded joints.

Write for Bulletin No. 59 or call Mid-Continent Supply Company

NAYLOR PIPE *Company*

1240 East 92nd Street, Chicago 19, Illinois

Eastern U. S. and Foreign Sales Office: 60 East 42nd Street, New York 17, N. Y.

EXCLUSIVE DISTRIBUTORS IN MID-CONTINENT AND GULF COAST AREAS: **MID-CONTINENT SUPPLY CO.** • Fort Worth, Texas and Branches

Soft Rubber Boots Prevent Injury to men or machines. A-B pendant stations are available with from 2 to 16 units, plus emergency stop unit in bottom of enclosure.

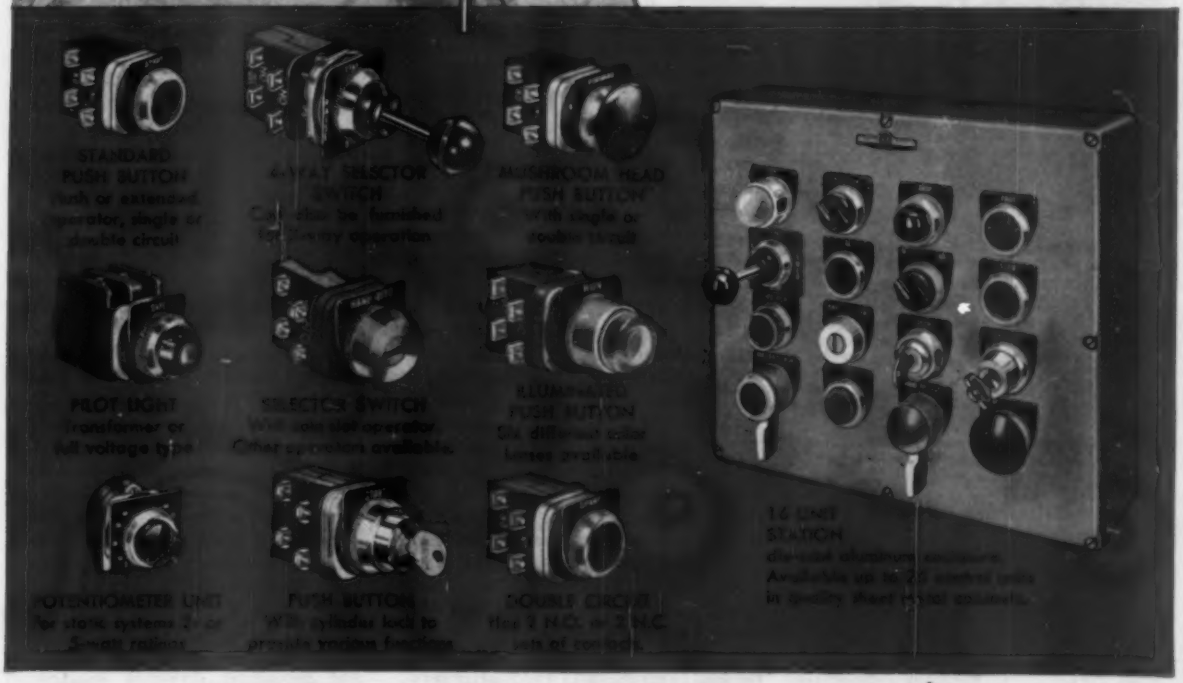
Allen-Bradley offers the

MOST COMPLETE LINE

of oiltight heavy-duty

CONTROL UNITS

The wide selection of Allen-Bradley Bulletin 800T push buttons and control units will enable you to satisfy each and every control station requirement. A-B control units and stations have seals to exclude oils and cutting fluids—contacts cannot become fouled. And *all* control units have the popular A-B double break, silver contacts that assure reliable operation—without maintenance. The rugged construction, flexibility, and generous wiring room of Allen-Bradley's Bulletin 800T line are "bonus" features. To get the best in every way—insist on Allen-Bradley. Send for Publication 6090, today.



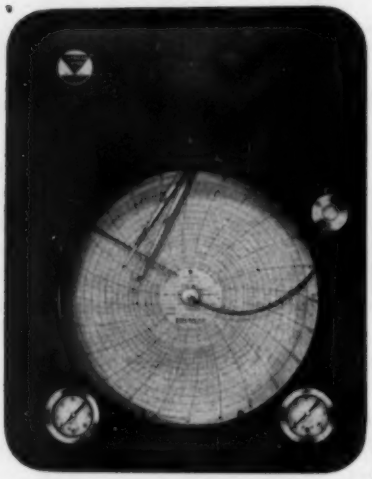
ALLEN-BRADLEY

Member of NEMA

QUALITY MOTOR CONTROL

Allen-Bradley Co., 214 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

AMERICAN®



SERIES
A-88
CONTROLLERS

Designed to give rugged, dependable performance, Series A-88 Controllers provide versatile, positive control of . . . Flow, Pressure, Liquid Level and other continuous process variables . . . accurately and automatically.

- Rugged, null-type non-bleed Relay.
- Simple, in-the-field linkage adjustment.
- Maximum Proportional Band changes with minimum output pressure changes.
- Proportional Band easily widened without disconnecting instrument tubing.
- Spring-closing Reset Valve sealed with bellows and calibrated according to time.

Ask for Bulletin CT-49.

AMERICAN® METER COMPANY
INCORPORATED ESTABLISHED 1892
General Offices: Philadelphia 16, Pa.
Sales Offices in Principal Cities

Management Personals

W. Dow Hamm was elected vice president of The Atlantic Refining Company. He was also appointed general manager of crude oil production. In this capacity he succeeds **Laurence A. Sunkel,** who will devote his attention to special crude oil production activities, pending his retirement early next year. Sunkel will continue as a director and a vice president of Atlantic. A graduate of the University of Oklahoma, Hamm joined Atlantic in 1942

W. D. Hamm

Dr. P. M. Pitts

as chief geologist. He has served as manager of domestic and foreign exploration since 1952.

Dr. Paul M. Pitts was named research manager in the firm's research and development department. In his new capacity Dr. Pitts directs basic research, application research, and development activities. **W. A. Myers,** acting general manager of the department, continues the direct supervision of the research services and crude oil production research.

William A. Fraser, manager of the materials department of the Venezuelan Atlantic Refining Company, has retired after 41 years with the firm. Fraser joined Atlantic in 1919 as a civil engineer and has held various positions in the crude oil production department including that of resident engineer in Cuba and Haiti.

Haylett O'Neill Jr. succeeds **A. J. Kelly** as general manager of the purchasing department of Humble Oil & Refining Company's Esso Standard division. Kelly retired March 1 after 41 years in Esso's purchasing activities. O'Neill transferred to New York from Houston, Texas, where he has been purchasing agent of the Humble division. His successor at Houston is **B. A. Warren,** assistant general manager of Esso Standard's purchasing activities.

Richard E. Keresey was appointed general counsel and **Carleton H. Endemann** associate general counsel by the Esso Standard division. Keresey joined the law department in 1955, after serving as assistant to the president of W. R. Grace & Company. The following year, he became Esso's associate general counsel. Keresey succeeds **Einar B. Paust,** recently named an assistant general counsel of Standard Oil Company (N. J.), Esso's parent company. Endemann succeeds Keresey as Esso's associate general counsel.

James N. Gorringe was appointed assistant manager of the employee relations department of Humble Oil & Refining Company. He will transfer to Humble's headquarters organization from New York City, where he has been serving as employee relations manager of the company's Esso Standard division.

H. D. "Ike" Moore was appointed president of the Derby Refining Company Division with headquarters at Wichita, Kansas, and elected a director of Colorado Oil and Gas Corporation. He is resigning as vice president and executive assistant to the president of Sinclair Oil Corporation, New York City.

Charles Carter was appointed district manager in the New York region of Grove Valve and Regulator Company. He will direct sales of valves and regulators in the Middle Atlantic and New England states, headquartered in New York City.

Cecil E. Schultz was appointed associate director of Continental Oil Company's production and pipeline accounting division. **E. B. Warwick,** methods analyst, is promoted to director of the office methods division, succeeding Schultz.

M. Dale McClure was appointed wage and salary administrator for Delhi-Taylor in Dallas. He reports to industrial relations manager **Al F. St. Peter.** Before joining Delhi, McClure worked in the employee and public relations department of Sohio Petroleum Company.

A. Y. Foster was appointed assistant manager of the Dallas accounting and service center for Mobil Oil Company. Foster, a member of the Mobil organization for 27 years, and during the past 12 years he has served in several capacities in the comptroller's department in New York. Most recently, he was assistant manager of the methods research department for Socony Mobil.

Henry H. Beeson was named natural gas coordinator for company operations throughout the United States, headquartering in Dallas. He will coordinate gas contract and policy matters among the company's exploration and producing divisions located at Houston and Midland, Texas; Denver and Los Angeles. He will also coordinate the company relationships with the Federal Power Commission and administer the negotiations of all gas sales and purchase contracts.

▸ **Warren Smith** was appointed assistant director of manufacturing sales for welding fittings and flanges of Midwest Piping Company, Inc., St. Louis. He will work with Midwest field representatives from coast to coast to implement distributor sales. His headquarters will be at Midwest's home office in St. Louis.

▸ **G. Gordon Biggar** was named vice president in charge of public relations for Shell Oil Company. He succeeds **H. L. Curtis,** retired. Curtis has been vice president since 1955. Biggar has been manager of the public relations department since 1952.

H. Frank Brown was named to succeed Biggar. Brown was of the visual aids division.

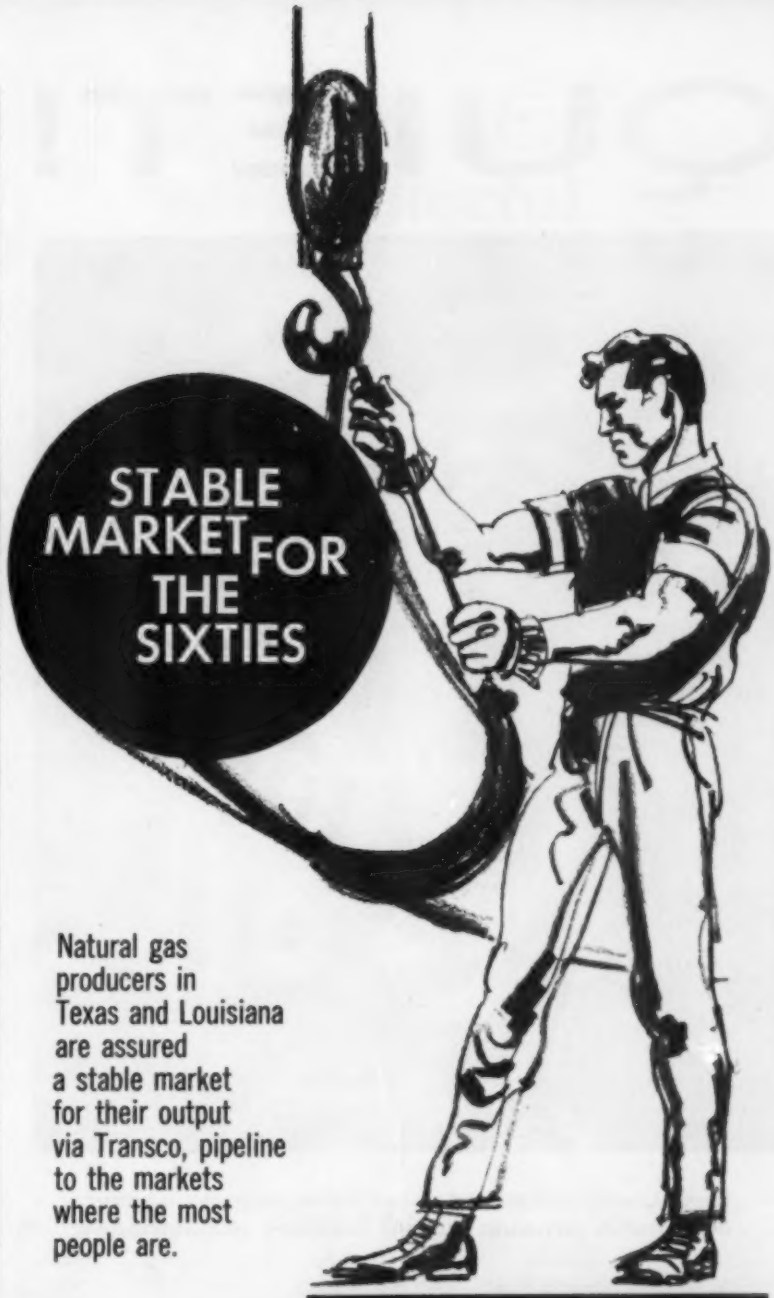
▸ Officers of Union Texas Natural Gas Company, a merger of Texas Natural Gasoline and Union Oil & Gas of Louisiana are as follows: **Richard T. Lyons,** president, chief executive officer; **John T. Oxley,** executive vice president, a director and a member of the Executive Committee; **William A. M. Burden** of New York, Chairman of the Board and **Mark J. Millard** of New York will become Chairman of the Executive Committee. New directors are **Frank M. Engle** and **Roger S. Randolph.**

▸ **Warren T. Bulla,** recently retired director of operations of Natural Gas Pipe Line, has become market consultant to the ASCOP Division of Electro-Mechanical Research, Inc. Bulla will assist in market development of the ASCOP Division industrial supervisory control, telemetering and remote annunciating equipment.

▸ **Albert Benjamin** was named director of public relations for Texaco Inc. Benjamin, who has been manager of the department's Latin American Division at Caracas, Venezuela, will succeed **Thomas D. Durrance,** who was appointed manager of public relations for Texaco's affiliate, Arabian American Oil Company.

▸ **Clark S. Teitsworth** retires May 17 as a director and senior vice president of Socony Mobil Oil Company, Inc., after 34 years' service. **George S. Dunham** will assume his responsibilities for the corporation's marine transportation, supply and distribution and purchasing departments. Dunham is also a member of the Socony Mobil board of directors. He will be proposed for election as a senior vice president on May 17.

Frank S. Cooper Jr. will assume Dunham's responsibility as executive vice president — Far East, of Mobil International Oil Company. Mobil International is the operating division of Socony Mobil outside of the United States and Canada.

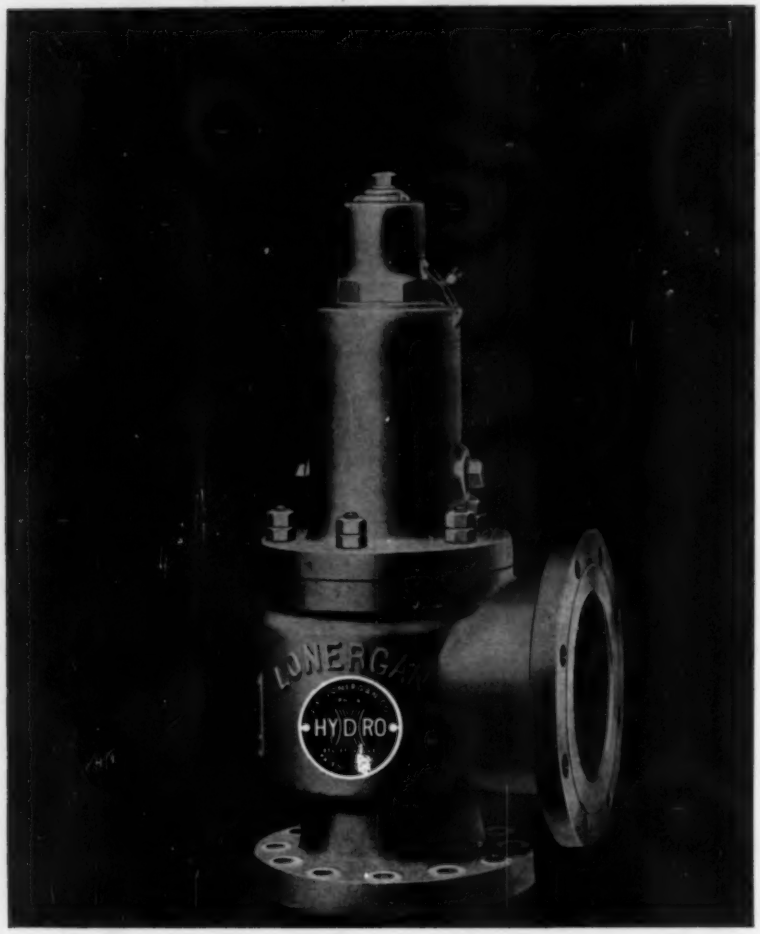


Natural gas producers in Texas and Louisiana are assured a stable market for their output via Transco, pipeline to the markets where the most people are.

TRANSCONTINENTAL GAS PIPE LINE CORPORATION

TRANSCONTINENTAL GAS PIPE LINE CORPORATION

QUIET!



New Lonergan liquid relief valve doesn't chatter; eliminates product waste; reduces maintenance

Ever hear a relief valve chatter? They all do! They shout their faults to the world, while beating themselves to death. When you can hear one, you know product is being wasted; maintenance costs are increasing; employees are growing annoyed; and perhaps dangerous, flammable liquids are running loose.

Now you can install a Lonergan Hydro-Valve guaranteed not to chatter, hammer, or drum, *yet still deliver full rated capacity !* Gone is the need to install an oversized valve or a high-priced, heavyweight regulator valve to eliminate chatter on by-pass and emergency relief applications.

The Lonergan Hydro-Valve does not contain any capacity-reducing gimmicks or gadgets to eliminate chatter. Instead, it is designed to be completely quiet under all operating conditions. It proves itself so on hundreds of applications every day.

Bellows models of the Lonergan Hydro-Valve are also available for corrosive applications. The elimination of chatter and its associated bellows flexing action, greatly extends bellows life and virtually ends the need for expensive bellows replacement. *Full details are in a Hydro-Valve bulletin. Write for a copy today !*

Lonergan

J. E. LONERGAN COMPANY, 205 RACE STREET
PHILADELPHIA 6, PENNA. • SINCE 1872

▸ **Eugene Hosford,** Houston, operations coordinator for the domestic production dept., Gulf Oil, is the new state chairman of the Oil Information Committee of Texas Mid-Continent Oil & Gas Association. Hosford will direct activities of 1500 volunteer oil men and women who are active in the Texas OIC programs. Formerly state OIC vice chairman, Hosford succeeds **K. H. Shaffer,** Houston, who is moving to New Orleans as president of The California Company.

Eugene Hosford

F. N. Mann

▸ **F. N. Mann** was appointed manager of the purchasing department, Atlantic Refining Company. He succeeds **J. S. Parks,** retired after nearly 45 years of service. Since 1945 Mann has served as director of the marketing personnel division.

▸ **O. P. Thomas** was elected to the board of directors of Sinclair Oil Corporation. A vice president since 1957, he was also designated an executive vice president, succeeding **Harry Jeffries,** who has reached retirement age, but continues as a director and chairman of the finance committee.

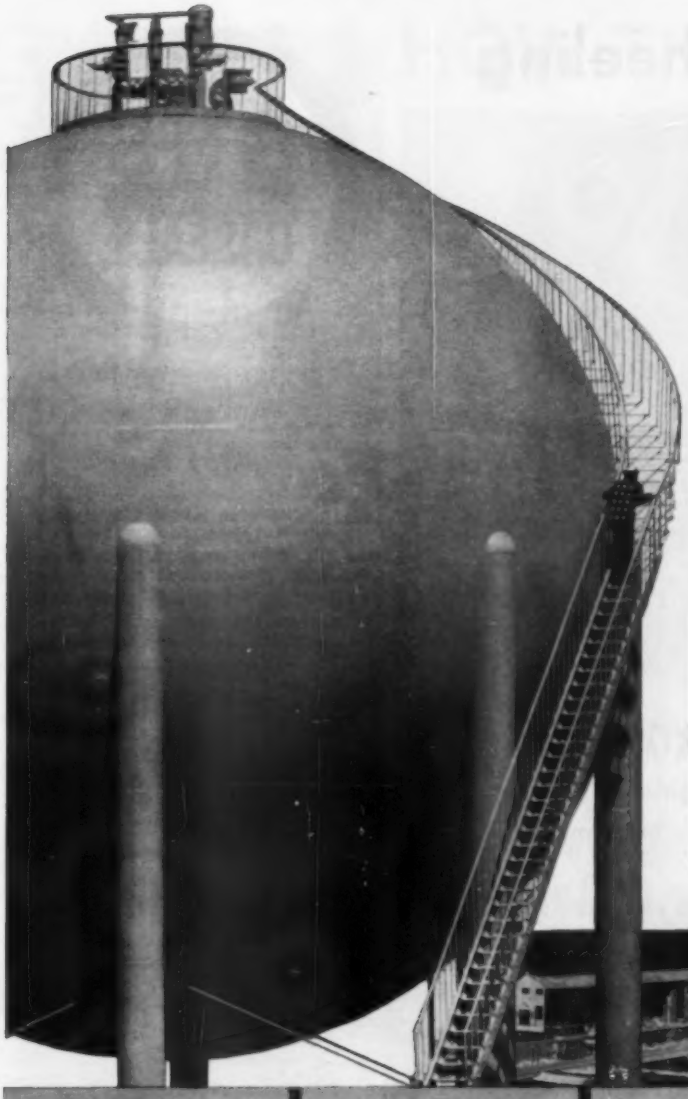
▸ **J. A. Skipton** and **W. C. Ballin** were appointed to the staff of the vice president of administrative services of the Ohio Oil Company. Skipton has been named assistant to the vice president and Ballin has been named public affairs coordinator. Both men formerly were members of the company's public relations division.

▸ **John D. (Jack) Nommensen** was appointed process pump product sales manager, Peerless Pump, Hydrodynamics Division, Food Machinery and Chemical Corp. He served as a sales engineer for the past five years in the Michigan area and his most recent post was that of branch manager of the Detroit office.

▸ **C. F. McCoy,** vice president and administrative coordinator for Sinclair Oil & Gas Company, Tulsa, has been elected to the company's board of directors.

▸ Jersey Standard announced that **E. G. Collado,** treasurer of the company, and **J. R. White,** president of Imperial Oil Ltd., of Canada, an affiliated company, have been designated candidates for election to the board of directors at Jersey Standard's annual meeting May 25.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

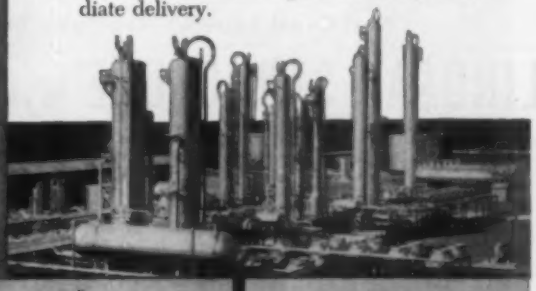


Tough, colorful, lasting beauty!

Take those pumps and rigs in the oil fields—or those tanks and pipelines in the refineries! Each needs the tough, colorful, lasting beauty that Rust-Oleum provides. If the surface is rusty, Rust-Oleum 769 Damp-Proof Red Primer can be applied *right over the sound rusted surface* after removing rust scale and loose rust. Special Rust-Oleum Oil Field Finishes match the original equipment colors on pumps and rigs – while other long-lasting Rust-Oleum coatings protect costly tanks and pipe lines.

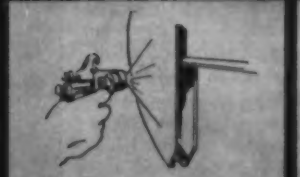
They're specially made for oil field use – tough, flexible, easy-to-use on the spot by brush or spray! They dry to firm, glossy finishes that resist sun, fumes, heat, moisture, weathering, and blowing dust and sand.

Try Rust-Oleum . . . your Rust-Oleum Distributor maintains complete stocks for immediate delivery.

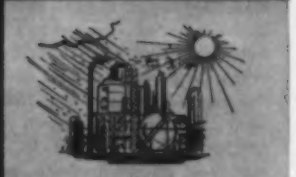


Apply Rust-Oleum 769 Damp-Proof Red Primer directly over sound rusted surfaces.

Follow-up with the Rust-Oleum finish coating in the color of your choice



By brush or spray – the Rust-Oleum system provides tough, colorful, lasting beauty.



Dries to a firm finish that resists sun, fumes, heat, weathering, and blowing dust and sand.

RUST-OLEUM®

There is only one Rust-Oleum. Distinctive as your own fingerprint.

STOPS RUST!®

Mail coupon today for FREE TEST SAMPLE

RUST-OLEUM CORPORATION
2632 Oakton Street, Evanston, Ill.
Dallas Branch: 3200 McKinney, Dallas, Tex.

- ☐ Free test sample of 769 Damp-Proof Red Primer to be applied directly over sound rusted surfaces.
- ☐ Complete literature with color charts.

COUPLINGS BY Wheeling

WHEELING MACHINE PRODUCTS CO.

Wheeling, West Virginia

West Coast Factory: Woodlake, California

GHS
WILLS-HERMETIC
GASEALS

Exclusive pressurized rings...
make a perfect metal-to-metal "wedding" for leak-proofing joints with pressures up to 20,000 lbs. p.s.i. and temperatures over 1000° F... *any joint, any shape, any size.*

GHS **Heavy Duty Re-Usable GASEALS Assure Safer, More Efficient Static Joint Seals for**

MISSILES ■ AVIATION ■ HYDRAULIC & PNEUMATIC SYSTEMS ■ DIESEL POWER MINING ■ OIL DRILLING & REFINING

...wherever high pressures and temperatures fight ordinary sealing methods.

Write or call today for GHS Gaseal Bulletin No. 160WH

GENERAL HERMETIC SEALING CORP.

GHS
99 E. HAWTHORNE AVE.
VALLEY STREAM, L.I., N.Y.
VAlley Stream 5-6363

GASEALS ■ HERMETIC SEALING SERVICES ■ MEGPOTS
TOGGLE SWITCHES ■ ELECTRONIC SUB-SYSTEMS

LINDSAY STRUCTURE withstands HEAT and WEATHER . . .

As housings for D-P Industrial Direct-Fired Gas Heaters!

The ruggedness of Lindsay Structure is demonstrated in these field installations — as a vital part of a Dryex gas recovery system. Exposed to all kinds of weather as the outer casing on oil field direct-fired gas heaters . . . which heat high pressure natural gas streams to temperatures that range from 600° F to 700° F . . . protecting equipment that builds gas stream pressures of from 500 to 1,500 pounds per square inch . . . Lindsay Structure housings meet all requirements, and also present an eye-pleasing appearance.

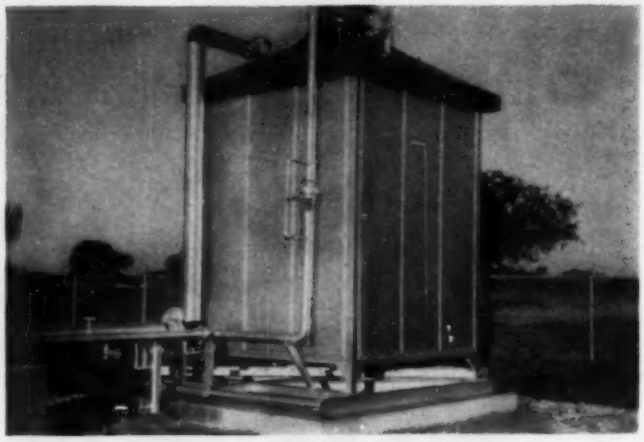
D-P Industrial uses Lindsay Structure components to form housings for direct-fired gas heaters in sizes from 2½ - 11 BTU per hour . . . just one example of many different applications made of Lindsay Structure in the exploration, recovery, processing, storage and transport of oil and natural gas. For full information regarding your specific application — write TODAY!

LINDSAY STRUCTURE DIVISION

INTERNATIONAL STEEL COMPANY

1631 Edgar Street • Evansville 7, Indiana

Canadian Affiliate: Lindsay-International, Port Credit, Ontario



Gentlemen: Please send me your informative folder . . . "TOOL KIT for building Housings, Enclosures, Containers, Processing Towers, Portable Shelters."

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

▸ **Walter C. Clemons,** presently divisional attorney for the Houston, Texas, law department, Gulf Oil Corporation, will become consultant counsel there and be responsible for general consultation with the Houston law staff. **W. B. Edwards,** presently an attorney on the staff of the general counsel in Pittsburgh, succeeds Clemons. He will be responsible for all litigation there, as well as being legal advisor and counsel for the departmental vice presidents headquartered in Houston. **Jesse P. Luton Jr.,** presently an attorney in the general law department, Houston, will become general attorney, remaining in Houston, and will be responsible for the general supervision of all litigation, including legal proceedings before administrative agencies in Washington, D.C., for Gulf Oil and its subsidiaries. All will be effective June 1.

▸ Plymouth Oil Company and Hiawatha Oil and Gas Company each have elected two new members of the board of directors. **E. L. Kennedy** and **R. L. Wentworth** have been elected to sit on the Plymouth board, and **D. L. Frawley** and **R. A. Vollmer** to the Hiawatha board.

▸ **Arnold F. Kaulakis** was appointed acting general manager of engineering at the Esso Research and Engineering Company. In his new post, Kaulakis will be responsible for the company's 800-man engineering force. He was director of the process research division, a post he held for almost three years.

Charles E. Paules, who was primarily responsible for the design and construction of 35 oil refineries around the world, has retired as a vice president of Esso. He also served on the board of directors of the company, which is the principal scientific affiliate of Standard Oil (New Jersey).

▸ **F. W. Steckmest,** manager of the employee communications department of Shell Oil Co., New York, was named chairman of the Advisory Committee on Employee Information of the American Petroleum Institute's Committee on Public Affairs. Steckmest succeeds **Luther Williams** of Sunray Mid-Continent Oil Co., Tulsa, Okla. He has been a member of the Advisory Committee since 1958.

DEATHS

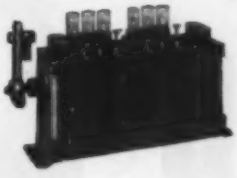
▸ Federal Power Commissioner **John B. Hussey,** 52, died suddenly March 17 in San Antonio, Texas, after he was stricken as he prepared to address a meeting of the Southern district of the American Petroleum Institute.

▸ **George Armistead Jr.,** proprietor of George Armistead and Company, suffered a fatal heart attack at his home in St. Michaels, Md., February 27.

HOW THIN can you

slice a drop of oil?

Whether you want to deliver several drops or the minutest fraction of a drop per piston stroke, a Manzel lubricator will do the job exactly. Manzel lubricators force oil of any viscosity against the high steam, gas and air pressure so common in modern compressors, engines and machines. They start, stop, speed up or slow down in synchronization with your equipment. Write for our catalog explaining the whole line. Manzel, 255 Babcock Street, Buffalo 10, New York. For efficient lubrication



ask the man from

UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

WHERE IN THE WORLD DO YOU NEED CONSTRUCTION?

OIL / GAS / WATER PRODUCTS / PIPELINE SYSTEMS

WILLIAMS BROTHERS

ENGINEERS - CONSTRUCTORS

NBT BUILDING, TULSA, OKLAHOMA / CABLE: WILLBRO

NEW YORK / WASHINGTON / LOUISVILLE
MINNEAPOLIS / CARACAS / BOGOTA / LA PAZ
EDMONTON / CALGARY / LONDON / ANKARA / TEHRAN

Stop leakers for good with

PB-80

PIPE JOINT COMPOUND

For EVERY USE and SERVICE CONDITION. Withstands temperatures to 500°F. — Pressures to 6000 psi! Not affected by gases, petroleum products, chemicals or steam and will not harden — joints sealed for years are easily broken. Economical — one compound for ALL needs.

For prices, complete specifications, write to

The SEALUBE Company

WAKEFIELD, MASS.

PROFITABLE PRODUCTION REQUIRES SOUND PLANNING

Oil and Gas Department

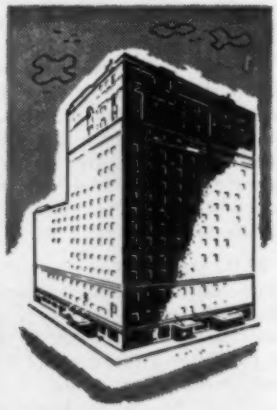
MERCANTILE

NATIONAL BANK

DALLAS, TEXAS

The Beautiful

Lamar



Houston's Hotel of Distinction

You'll like the extra luxuries and comforts which distinguish The Lamar... It's completely air-conditioned of course, with TV and radio in guest rooms. And food to please the most discriminating. Rates begin at $4.50. Garage Service.

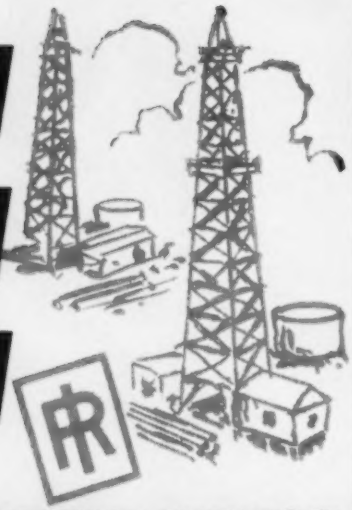
GEORGE B. ADAMS
General Manager

IN THE HEART OF THE THEATRE & SHOPPING DISTRICT

"THE percentage depletion provision in our tax laws is deeply rooted in the economics of the oil business... It has been an incentive which has helped provide this country for decades with an abundant supply of oil."—*from the 1959 Annual Report*

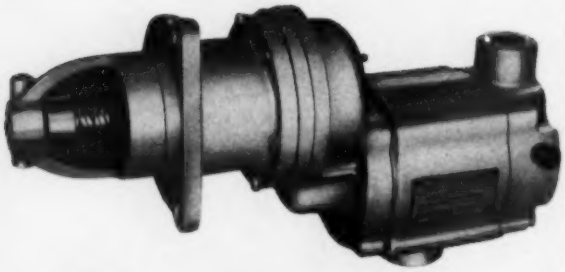
STANDARD OIL COMPANY (NEW JERSEY)

new new new



AIR STARTING MOTOR

50% MORE POWER...
on 30% LESS AIR...
10 LBS. LIGHTER!



Handles diesels up to 2300 cu. in. displacement; gasoline engines up to 4600 cu. in.

- **Outperforms all others of comparable size.**
- **Fully interchangeable with electric starters.**
- **Eliminates costly generators and batteries.**
- **Starts a cold, sluggish engine quickly, and easily.**

For details on the savings possible with the all new Size 10BM, or I-R's complete line of Air Starting Motors, write for a copy of 24-page "Go Modern—Start with Air."

A 45A-18

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

Books To Read . . .

▸ **Engineering Manual.** *A Practical Reference of Data and Methods in Architectural, Chemical, Civil, Electrical, Mechanical, and Nuclear Engineering. Robert H. Perry, editor-in-chief. Published by McGraw-Hill Book Company, 330 West 42nd Street, New York 36, New York. Price, $9.50.*

Commonly used formulas, data, and methods in the principal engineering fields are brought together in one volume prepared by a staff of specialists headed by Dr. Perry, who is associate professor of chemical engineering at the University of Oklahoma. Separate sections are devoted to the fields of architectural, chemical, civil, electrical, mechanical, and nuclear engineering. The three sections at the front of the book contains mathematics, tables, and physical and chemical data common to the major engineering sciences. In general, overlap has been kept to a minimum, and the engineer is guided to desired material through extensive indexing and cross referencing.

▸ **Leader Behavior: Its Description and Measurement,** *edited by Ralph M. Stogdill and Alvin E. Coons. Published by The Bureau of Business Research, College of Commerce and Administration, The Ohio State University, Columbus 10, Ohio. Pages, 168. Price $2.*

This monograph consists of a collection of papers by staff members of the Ohio State Leadership Studies. The papers describe the development, analysis and application of a set of items devised for the description of the leader behavior of business executives, foremen, teachers, college administrators, Air Force officers and Navy officers. Data on the relation of leader behavior to effectiveness measures, group descriptions and attitude climate are presented. A copy of the Leader Behavior Descriptions Questionnaire and directions for its use are also included. Although this book was published in 1957 it continues to be timely and useful.

▸ **Principles and Practice of Flow Meter Engineering,** *by L. K. Spink. Eighth edition. Published by The Foxboro Company, Foxboro, Massachusetts. Pages, 549. Price, $15.*

Newest edition of this handbook by a leading authority on flow measurement is much broader in scope than any previous edition. It covers latest developments in flow measurement, including new primary devices and different tap locations, and touches on the basic principles of secondary elements. Though written primarily as a textbook, it is so conveniently arranged that it loses none of its usefulness as a handbook for everyday use in commercial measurement. Electronic computers have been used to provide many new labor-saving tables.

▸ **Evaluating and Using Business Indicators.** *A Management Report published by Finance Division, American Management Association, Inc., 1515 Broadway, Times Square, New York 36, New York. Pages, 159. Price $3.75.*

This forecasting handbook is crammed with economic indicators. One of the AMA reports that has proved very useful, it is a collection of articles by people in the interpretating business. Represented in the author list are executives of National Bureau of Economics Research, Investment Bankers Association of America, Dresser Industries, U. S. Steel, General Motors, Lionel D. Edie & Company, and others.

The foreword points out the importance of timing and suggests that management can sharpen its timing by using those business indicators that can reveal a pattern of future economic activity and that can be correlated with the company's operation. The collection of articles is to provide a clear view of what business indicators can and cannot do for management. Although published early last year, the reports will give excellent background statistics that can be used in many forecasts.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

World Oil, *published by International Review Service, 15 Washington Place, New York 3, New York. Pages, 64. Price, $2.50.*

Although this report is sketchy, it does touch on some background material that is not easy to find sometimes. It goes briefly into economics, social and political situations in various countries. International Review Service is an independent editorial organization that collects and condenses background material on various situations.

Our attention was called to the organization by a report of a luncheon sponsored by IRS at the United Nations. At this luncheon Howard A. Cowden, secretary-treasurer of the International Cooperative Petroleum Association and president of Consumers Cooperative Association of Kansas City, called the largest petroleum cooperative in the world, was a speaker. He urged that countries seeking ways to develop their oil resources make sure that their wealth was not slackened off by big oil corporations whose ownership is centered in other countries.

C. V. Narasimhan, United Nations Under Secretary for Special Political Affairs, said that U.N. stood ready to provide assistance to countries requesting aid in developing their oil resources.

"World Oil" goes very briefly into international operations. There's a chronological table which uses international dates. An appendix carries Middle East oil concessions and a number of tables on production, world movements, imports, exports, refinery production, etc.

Petroleum Products Handbook. *Edited by Virgil B. Guthrie. Published by McGraw-Hill Book Company, 330 West 42nd Street, New York 36, New York. Pages, 864. Price, $18.50.*

This is a master reference of methods, information, and data to help oil companies and large-scale users of commercial petroleum products in efficient storage, handling, and utilization of these products. Thirty-two specialists cover gasoline, liquefied petroleum gas, aircraft fuels, diesel fuels, heating oils, residual fuel oils, greases, waxes, petrochemicals, asphalt, coke, and others. Additives are classified and their functions defined. A reference data directory is provided, enabling the reader to locate quickly all published sources of current data on tests and specifications, storage, handling, shipping regulations, etc.

Standards of the Tubular Exchanger Manufacturers Association. *Published by Tubular Exchanger Manufacturers Association, 53 Park Place, New York 7, New York. Pages, 144. Price, $6 in U. S.; $7 foreign.*

Fourth edition of this widely used handbook has information on the design and engineering of tubular heat exchangers not available from any other source. It contains sections outlining the mechanical standards for both Class R and Class C exchangers, plus a wealth of thermal data, material specifications, and general design information. Certain reference material in fields now undergoing extensive developmental changes was eliminated from the current edition to reduce the need for continued revisions.

Rocket Propellant Handbook, *by Boris Kit and Douglas S. Evered. Published by The Macmillan Company, 60 Fifth Avenue, New York 11, New York. Pages, 354. Price, $12.50.*

This book represents a milestone in rocket technology, for prior to its publication little had been done to assemble, evaluate, and synthesize material from individual papers into a usable handbook on substances which may serve as rocket propellants. The authors describe nearly 100 chemicals which have possible use as rocket propellants. Each substance is analyzed as to its general characteristics, physical and chemical properties, methods of storing and handling, and performance characteristics.

ORIFICE FLANGE

standard meter tubes

Here's just the ticket for minimum-cost metering stations . . . Daniel Orifice Flange Standard meter tubes. Used where frequent plate inspection is unnecessary, these units provide completely reliable flow measurement. Daniel orifice flanges are precision machined from the finest materials available to meet current AGA, ASA and ASME requirements. Each standard tube is shipped complete with a bored and polished stainless steel orifice plate, bolts or studs, jackscrews and steel pipe plugs. See your Daniel representative for full details.

for orifice flow measurment in all sizes, pressures and services

DANIEL

ORIFICE FITTING COMPANY

INCORPORATED

Houston, Texas
P. O. Box 19097
HOmestead 5-3451

Los Angeles, California
3352 Union Pacific Ave.
ANgelus 9-9206

Write for Daniel Catalog Section "D"

NOW... a new, powerful electronic system to automatically monitor and control your industrial processes

THE RCA 110

INDUSTRIAL COMPUTER SYSTEM

Designed by RCA for modern industrial control of all major industries, the RCA 110 provides unprecedented capabilities for off-line and on-line data accumulation, and for real time automatic control of industrial systems. For applications as diversified as economic distribution and generation of electrical power for public utilities, systematic production control in the metal working industry, on-line control of entire petrochemical plants, the RCA 110 is universally adept.

The RCA 110 Industrial Computer System offers efficient and highly advanced concepts of automated process control for maximum payout in modern industrial applications. The RCA 110 is also available with instrumentation by the Foxboro Company. For detailed information, contact your local Foxboro representative or write to: Industrial Computer Systems, Electronic Data Processing Division, Radio Corporation of America, Camden 2, New Jersey.

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

Nationwide RCA service organization gives unexcelled customer assistance to 110 Industrial Computer users.

NEW

RCA 110

INDUSTRIAL COMPUTER SYSTEM

RCA, with the experience gained as a major supplier of *electronic data processing* systems for business, originates a truly modern computer system for industry. Here are the features that bring you unlimited potential for process control progress.

NOW — virtually unlimited number of analog or on-off inputs plus a wide variety of conventional input/output equipment can be integrated with the computer for complete system flexibility

NOW — automatic program interrupt by which control points can "on demand" take over the computer for instantaneous handling of critical tolerances or safety factors

NOW — computer logic accepts decimal or binary information; powerful instruction code provides complete flexibility including automatic priority handling of control functions

NOW — high speed computation, with fast random access core memory in combination with 3600 rpm memory drums, results in highly effective overall system speed

NOW — expansibility, in natural stages of process-control development, economically implemented by "building block" concept

NOW — all transistor, printed circuit construction assures highest reliability. Diagnostic routines for self-checking, *during operation*

NOW — easy maintenance with plug-in components and slide-out sub-assembly drawers. Serviceable during operation. Rugged, heavy-duty construction; cabinet may be pressurized. Does not require internal air conditioning.

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

Meetings . . .

May 16-17 — International Society of Professional Well Log Analysts, annual meeting, Tulsa Hotel, Tulsa, Okla.

May 22-June 10 — Short Course in Reservoir Engineering, Pennsylvania State University, University Park, Pa.

May 23-26 — American Society of Mechanical Engineers, Oil and Gas Power Division Conference, Hotel Muehlebach, Kansas City, Mo.

May 23-24 — American Gas Assn., production meeting, Roosevelt Hotel, New York, N.Y.

May 25-28 — American Assn. of Petroleum Geologists, Western Canada regional meeting, Banff Springs Hotel, Banff, Alta.

May 26-27 — Rocky Mountain Oil & Gas Assn., annual refining meeting, Newhouse Hotel, Salt Lake City, Utah.

June 1-3 — Appalachian Underground Corrosion Short Course, West Virginia University, Morgantown.

June 1-3 — Short Course in Gas Technology, Texas College of Arts and Industries, Kingsville, Tex.

June 2 — Pennsylvania Grade Crude Oil Assn., annual meeting, Pennhills Club, Bradford, Pa.

June 2-3 — Kentucky Oil & Gas Assn., annual meeting, Phoenix Hotel, Lexington, Kentucky.

June 8-11 — National Society of Professional Engineers, annual meeting, Statler Hotel, Boston, Mass.

June 9-11 — Interstate Oil Compact Commission, midyear meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

June 12-17 — API Division of Production, mid-year committee conference, Sheraton-Dallas Hotel, Dallas, Tex.

June 22-25 — American Assn. of Petroleum Landmen, annual national convention, Ambassador Hotel, Los Angeles, Calif.

June 26-28 — North American Gasoline Tax Conference, annual meeting, southern region, Eden Roc Hotel, Miami Beach, Fla.

June 25-29 — Petroleum Equipment Suppliers Assn., silver anniversary meeting, Banff Springs Hotel, Banff, Alta.

July 28-30 — API Division of Production, eastern district meeting, Greenbrier Hotel, White Sulphur Springs, W. Va.

Aug. 15-17 — American Society of Mechanical Engineers — American Institute of Chemical Engineers, heat transfer conference and exhibit, Statler Hilton Hotel, Buffalo, N. Y.

Sept. 11-16 — American Chemical Society, national meeting, New York City.

Sept. 14-16 — National Petroleum Assn., annual meeting, Traymore Hotel, Atlantic City, N. J.

Sept. 15 — Natural Gasoline Assn. of America, Rocky Mountain regional meeting, Palliser Hotel, Calgary, Alberta, Canada.

Sept. 18-21 — American Society of Mechanical Engineers, petroleum mechanical engineering conference, Jung Hotel, New Orleans, La.

Sept. 19-21 — Texas Mid-Continent Oil & Gas Assn. annual meeting, Hilton Hotel, San Antonio, Tex.

Sept. 25-27 — American Assn. of Oilwell Drilling Contractors, annual meeting, Roosevelt Hotel, New Orleans, La.

Sept. 25-28 — American Institute of Electrical Engineers, petroleum industry committee, Hotel Skirvin, Oklahoma City, Okla.

Sept. 29-30 — Mid-Continent Oil & Gas Assn., Mississippi-Alabama division meeting, Grand Hotel, Point Clear, Ala.

Oct. 2-5 — Society of Petroleum Engineers of AIME, annual fall meeting, Denver, Colo.

Laugh with Barney

They also have a slogan in Russia: "Vote for the party. The life you save may be your own."

Roughneck: Hello, Homer, why such a happy expression?

Roustabout: I just got a cute dog for my wife.

Roughneck: Gee Whiz, man! Sure wish I could make a good trade like that!

Mama: "I'm so glad to see you sitting so quiet while your father naps."

Junior: "I'm watching his cigarette burn down to his fingers."

A young wife of our acquaintance could teach her older married sisters a thing or two about how to keep a husband from working late night after night at the office. Three times in one week, her spouse had called to say he would be detained by a spate of unexpected work.

The fourth time it happened, she accepted it calmly as before. But just before hanging up, she inquired sweetly, "John, can I DEPEND on that?"

He's getting all his work done during office hours these days.

The young man looked at the high prices on the night club menu and said to his date, "What will you have, my plump doll?"

Some folks can stay longer in an hour than others can in a week.

Most children are descended from a long line—their mothers once listened to.

An Indian guide drove with some tourists far back into the wilderness to show them some ancient Indian ruins. In order to reach the ruins, they finally had to leave the car and walk some distance. After a considerable hike, one of the tourists suddenly exclaimed, "Gracious, I forgot to lock the car!"

The Indian guide solemnly replied, "Don't worry. There isn't a white man within 25 miles of this place."

Two ladies in a car quarreled about the window, and at last called the conductor as referee.

"If this window is open," one declared, "I shall catch cold, and will probably die."

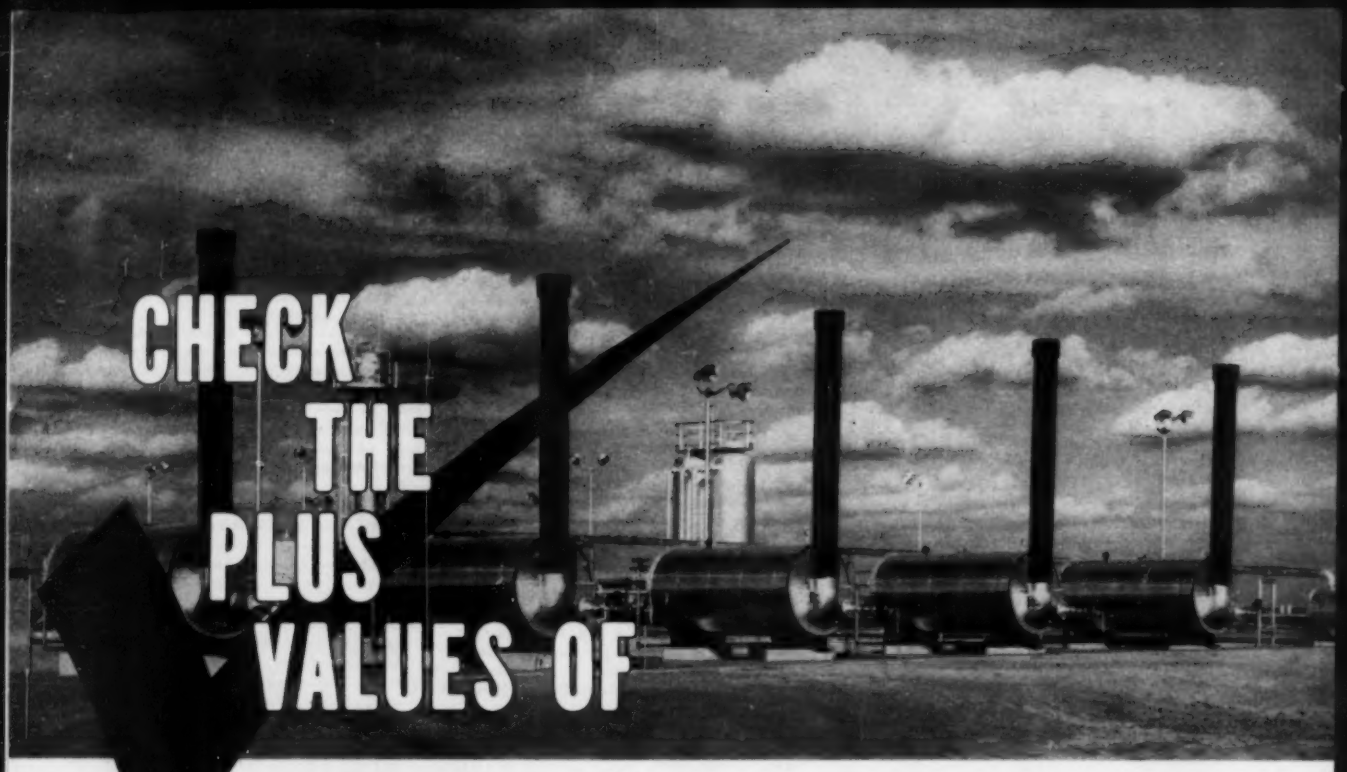
"If the window is shut," the other announced, "I shall certainly suffocate." The two glared at each other.

The conductor was at a loss, but he welcomed the words of a man who sat near, who said:

"First, open the window, conductor, that will kill one. Next shut it. That will kill the other. Then we can have peace."

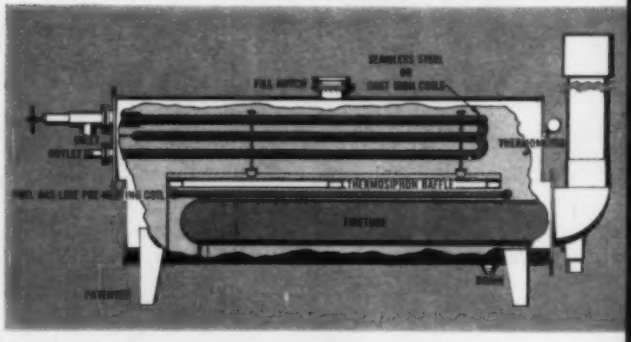
A chivalrous man is one inclined to protect a woman from every man except himself.

Keeping a secret from some people is like trying to smuggle daylight past a rooster.



NATIONAL® INDIRECT HEATERS

- ✓ Controlled water bath circulation
- ✓ Increased bath-side coil heat transfer rates
- ✓ Lower firetube skin temperatures
- ✓ Lowest obtainable water consumption because of water circulation
- ✓ SAFETY-DRILLED H.P. return bends
- ✓ Removable firetubes
- ✓ Removable tube bundles
- ✓ Large fill hatch (convenient for filling, and to inspect coils)
- ✓ Large firetube combustion volume per square foot of firetube area
- ✓ Engineers and field crews available from all warehouse points to size, install and service National Indirect Heaters
- ✓ Large stocks of all sizes of coils at plant
- ✓ Real and actual quality fabrication
- ✓ X-ray and stress relieving facilities (when stress relieving is done, **the whole coil is stress relieved — not just the return bends)**
- ✓ Over 50 service and warehouse stocking points for complete units or spare parts



FOR COMPLETE INFORMATION, WRITE FOR CATALOG 700-1 CONTAINING DETAILED CAPACITIES, SIZES AND REASONS

It's a National®

NATIONAL TANK COMPANY

DRAWER 1710

TULSA, OKLAHOMA

WHY USE A POWER SAW TO CUT A TWIG?

CABOT SAYS: WHY SPEND MORE FOR A PUMPING UNIT THAN YOU NEED TO?

Producing at a minimum cost is essential in today's oil economy. That's why Cabot works at holding your pumping costs down. Cabot concentrates on engineering, workmanship and quality to build dependable pumping units.

. . . And Cabot backs its units with 24 hour field service. Get the Cabot habit! . . . Call your J & L man . . .

CALL YOUR J&L MAN...

• OIL FIELD PUMPING EQUIPMENT •
CABOT
PAMPA, TEXAS
FRANKS
DIVISION OF CABOT

Most Anyone Can Put Holes In A Pipe

Some oil men think that completing a well means nothing more than putting holes in a pipe. Most anybody can do that.

But Welex Completion Services offer more than holes in the pipe. That's why selection of Welex to complete your well is so important.

Welex's well-rounded Completion Services go far beyond "just putting holes in pipe." To you, this may mean the difference between winning and losing a million dollar gamble a mile or two or more underground.

Why is Welex the best choice? There are many reasons. For example:

What if the well presents special completion problems—problems such as high temperatures or high pressures? Welex has a large staff of specially trained engineers, ready to tackle each individual well and map out the most effective completion program.

What about cost? If you want nothing more than holes in your pipe, you may find someone cheaper. But why risk a million dollar investment by choosing a company a few dollars cheaper in price but thousands of dollars short in experience and know-how.

What about new services? Through the years Welex has always led the field in offering new, proven Completion Services. As originator of jet perforating, Welex has more experience and technical know-how in this field than any other company. Welex's research engineers already are working on new developments that will become standards of the industry in the future, just as many of their past developments are now standards.

What about different types of wells? Here's another important question—and answer which again makes Welex the best choice. Welex is the *only* wireline service company offering a *complete* selection of Completion Services for *every* well condition, whether cased hole, through tubing, tubingless or open hole.

And speaking of hole conditions, Welex has the most complete selection of perforating guns for every type of hole. Let Welex's experienced engineers solve your completion problems.

Experience?

There's no substitute for experience.

In well completions, the company with the most experience is the logical choice.

When you select Welex, originator of jet perforating, you're getting the company that engineered and developed most of today's modern Completion Services. Welex has the know-how, gained from research and field experience, to solve any completion problem.

And for optimum size hole perforations and deepest penetration, proven jet charges from Welex research facilities out-perform all others—both in laboratory tests and in your well.

WELEX, INC.

ORIGINATORS OF JET PERFORATING — Welex

General Offices: 1400 East Berry, Fort Worth, Texas
In Canada: Welex of Canada, Ltd.

Of Things To Come . . . In Oil

2.7 BILLION BBL POTENTIAL FOR SPRABERRY is estimate of U. S. Bureau of Mines as result of a 6-month study of the 300,000-acre trend in West Texas. A study of only 16,000 acres in the trend using radioactive tracer gases to outline the main fracture pattern indicated ultimate potential recovery for this portion to be about 19 million bbl. About 10 percent of Spraberry oil will be produced by primary methods.

TUBINGLESS COMPLETIONS ARE GAINING in popularity, according to reports from operators at the API Southern District meeting concluded recently in San Antonio. Louisiana will hold hearings this month for approval of such installations in the Pelican State. New and improved equipment is now available, even for pressures up to 6000 psi. Deepest to date is believed to be around 11,000 ft.

CUT DRILLING AND PRODUCING COSTS ONE-THIRD to one-half in the next 10 years . . . this is the condition put before petroleum engineers by Marion Stekoll, president of Stekoll Petroleum Company of Dallas, if the U. S. oil industry is to remain vigorous. The future belongs to the dissatisfied engineer who will not accept the status quo and who can 'wildcat' with ideas.

FUTURE SHAPE OF ULTRA-DEEP WELLS can be found in the recent world's record slim hole drilled for H. L. Hunt Oil Company by Penrod Drilling Company near the Texas-Mexico border in Webb County. Bottomed at 20,603 ft, the last 1500 ft were drilled with a 3¾-in. diamond bit. Although well was abandoned, no trouble was encountered in the drilling operations which averaged over 100 ft per day in the ultra-slim hole.

OFFSHORE OIL WILL BE LOWEST-COST OIL found in the U. S. according to *Perspective*, publication of Wall Street's Calvin Bullock. Final settlement of dispute between the states and federal government over ownership of land between 3 and 10-mile limit is expected from the Supreme Court this year. Expected technological improvements include conquest of the deep-water barrier and construction of underwater storage tanks to lessen need for more pipelines. Although total cost figures will remain high, per-barrel figures will show Gulf Coast oil to be "lowest-cost petroleum reserve in the United States."

A superior thru-tubing jet perforator featuring:

ENCLOSED FIRING SYSTEM

MINIMUM DEBRIS

DEEP, CARROT-FREE PENETRATION

HIGH WELL FLOW INDEX

ALL NEW McCULLOUGH *mac-jet*

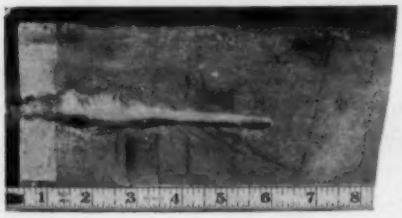
The McCullough Mac-Jet is an all-new development in expendable jet perforating – designed to provide maximum perforating efficiency – to obtain highest production from thru-tubing and slim hole completions.

- Enclosed Firing System – Each Mac-Jet unit is self-contained, including jet charge and integrated firing system, enclosed in a frangible, high strength case. This design eliminates the use of exposed primacord. Units are securely locked together and may be fired from bottom up or from top down.
- Minimum Debris – Entire Mac-Jet Perforator breaks up into small bits when fired. Mac-Jet units, spacers and bottom firing assembly are all disintegrating to assure complete break-up.
- Superior Perforation Characteristics – "big gun" performance – penetration equal to or better than that of many larger jet casing guns. Carrot-free perforations, large deep holes, high well flow index.
- Size, Shot Density, Length – 1 11/16" OD and 2 1/16" OD Standard shot density is four per foot, 90° phasing.

Disintegrating spacers are supplied to provide fewer shots per foot when required. Any number of Mac-Jet units may be run in any length desired.

SPECIFICATIONS:

	1 11/16" OD	2 1/16" OD
Pressure, Temperature Rating	15,000 psi. @ 300°	13,500 psi. @ 300°
Maximum Temperature	350°	350°
Total Charge Weight	12 grams	20 grams
Av. Penetration (Berea Sandstone)	5.69"	7.45"
Av. Entrance Hole	13/32"	3/4"
Av. Well Flow Index	1.1+	1.44
Fill-up – 1' Gun, 5 1/2" Casing	1"	–
Fill-up – 1' Gun, 7" Casing	1/2"	1"



Standard Berea Sandstone target perforated by 1 11/16" OD Mac-Jet. Average penetration, 5.69"; average entrance hole size, 13/32; average well flow index, 1.1+.

DISINTEGRATING SPACER – Available in various lengths to provide fewer than four shots per foot. Disintegrates into small bits when perforator is fired.

McCullough *TOOL COMPANY*

LOS ANGELES • HOUSTON • EDMONTON • *CABLE ADDRESS: MACTOOL*

Look at those big birds standing all over the Earth, flapping their wings and pecking the ground!

MARS

EARTH OR BUST!

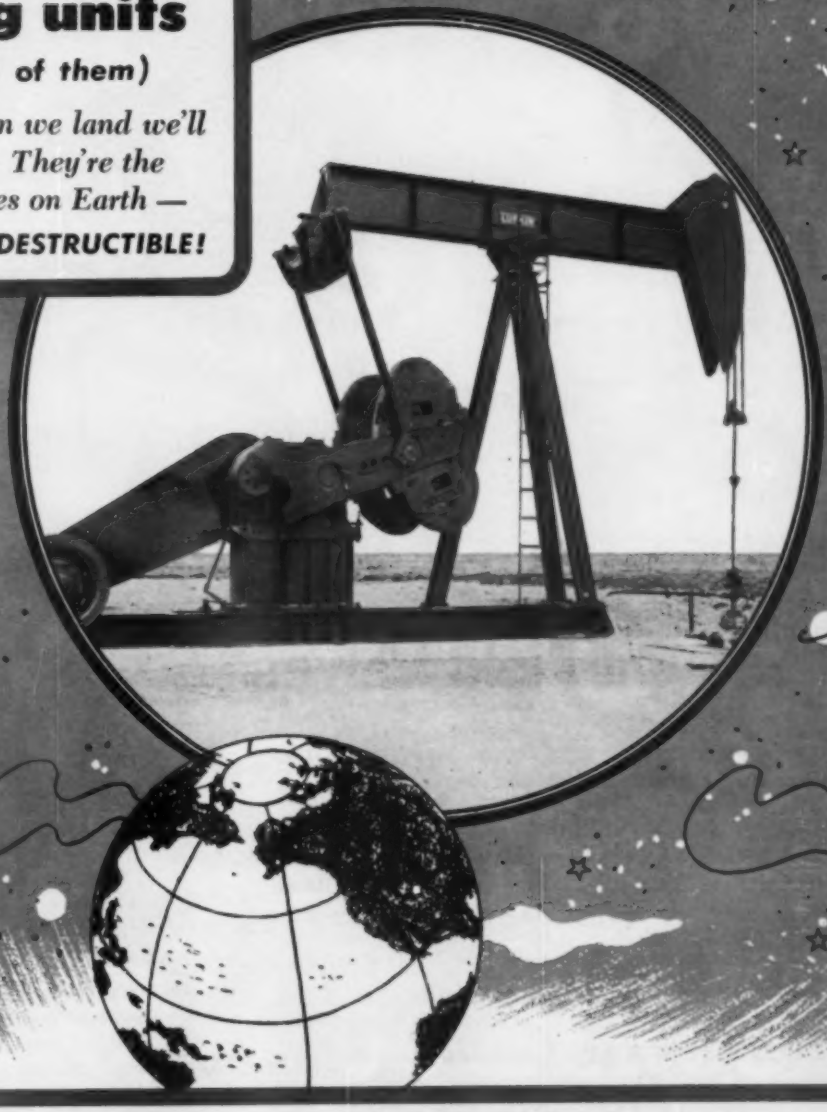
Those are not birds — they're

LUFKIN
pumping units

(over 67000 of them)

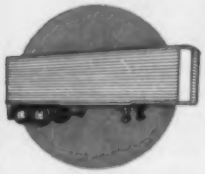
If we hit one when we land we'll be torn to bits. They're the toughest machines on Earth —

PRACTICALLY INDESTRUCTIBLE!



PUMPING UNITS

GAS ENGINES



TRAILERS

SPEED INCREASERS AND REDUCERS

LUFKIN FOUNDRY & MACHINE COMPANY

LUFKIN, TEXAS

Branch Sales and Service

HOUSTON • NATCHEZ • CORPUS CHRISTI • LAFAYETTE • DALLAS • KILGORE • ODESSA • HOBBS • GREAT BEND • DENVER
SHREVEPORT • WICHITA FALLS • LOS ANGELES • BAKERSFIELD • EFFINGHAM • CASPER • OKLAHOMA CITY • SIDNEY • MIDLAND
FARMINGTON • SEMINOLE • TULSA • NEW YORK • PAMPA • STERLING • MARACAIBO, VENEZUELA • ANACO, VENEZUELA

Lufkin equipment in Canada is handled by
THE LUFKIN MACHINE CO., LTD., 9950 65th Avenue, Edmonton, Alberta, Canada, Regina, Saskatchewan, Canada

"We wouldn't use any other valve!"

W-K-M® Oil Field Valves

No other valves give the same dependable service and lifetime economy. No other valves seal so tight.

W-K-M's Controlled Force Seating creates an initial bubble-tight seal between the gate and Teflon inserts. As the gate assembly expands, a tight metal-to-metal seal is achieved. Result: a perfect *Double Tight Seal* without body or seat lubrication.

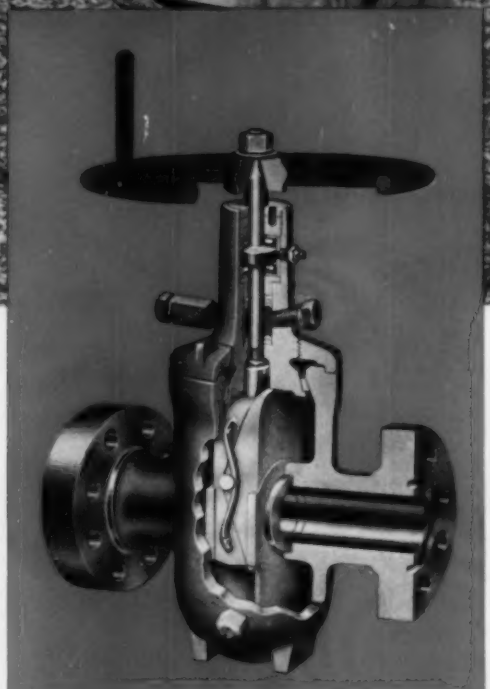
Next time—and every time—specify W-K-M! *Available at leading supply stores everywhere.*

PRODUCT OF W-K-M's *Creative Engineering*

WRITE FOR CATALOG 200

W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS



W-K-M Through-Conduit Gate Valves feature pressure seal bonnets, superfinished stems supported on roller bearings, seating surfaces sealed from the lading flow — and can be overhauled on-the-line.

Sizes: 2", 2½", 3" and 4".

Working Pressures: 1000-5000 psi (model illustrated above); other models 500 to 15,000 psi.

5917-R

"This GUIBERSON DRILLABLE PACKER runs, sets and drills faster than any other permanent packer"

HERE'S WHY!

Guiberson Type A Drillable Packer..

REDUCES PREMATURE SETTING Casing drag and junk impact are transmitted through the mandrel shoulder directly to tubing string.

REQUIRES ONLY ONE-HALF TUBING TRIP to set and place in production . . sets on wire line, too.

REQUIRES LESS SETTING FORCE Spring loaded lower slips are held drag-free from the casing until packer is set . . teeth remain sharp.

REQUIRES LESS DRILLING TO REMOVE Top slips are first part drilled. After drilling through them, packer can be fished out, or ½ to ⅔ of packer can be drilled and rest pushed to bottom of hole.

USES A SUPERIOR, OIL FIELD PROVED PACKING ELEMENT . . made in Guiberson plant.

FORMS A POSITIVE SEAL Unique internal mandrel shoulder expands packing element. All weight and high pressures are transmitted to packing element for a positive seal.

Compare Guiberson Drillable Packers for single or multiple-zone production . . acidizing . . pressuring operations . . water-flooding . . testing . . corrosion control . . many other completion jobs. Their speed and efficiency of setting and positive seal cut operating and replacement costs.

There's a Guiberson packer for every drillable packer application . . See your Guiberson man

TYPE A — With flapper valve and junk pusher

TYPE AN — No flapper valve.

TYPE AG — No flapper valve . . has guide body in place of junk pusher

TYPE AT — Has integral tail pipe connection . . no flapper valve

TYPE W — Small diameter . . wire line set only

TYPE AR — Small mandrel ID . . with flapper valve

TYPE ANR — Small mandrel ID . . no flapper valve

TYPE AGR — Small mandrel ID . . has guide body

TYPE A2R — Doubly restricted mandrel ID

Sold by Oil Field Supply Stores Everywhere

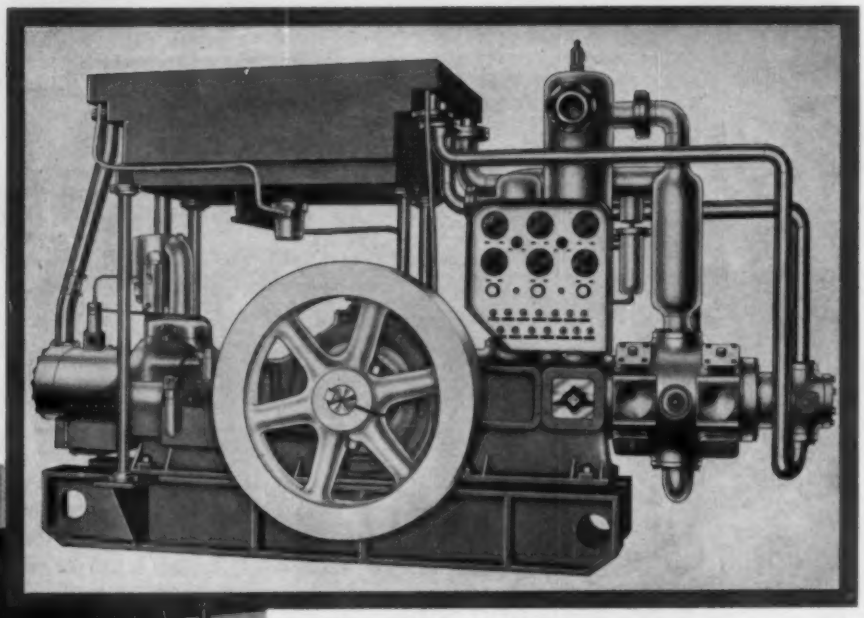
GUIBERSON

THE GUIBERSON CORPORATION

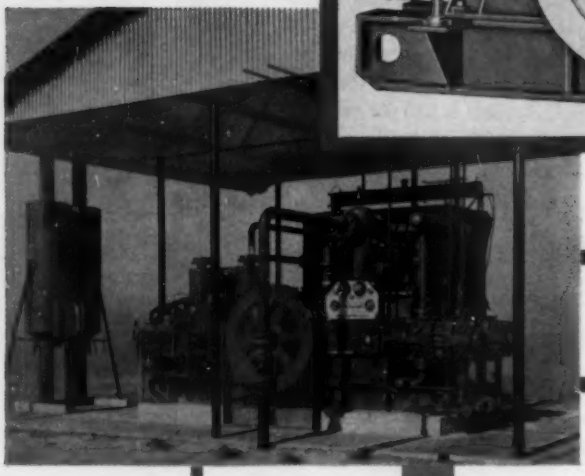
ESTABLISHED 1919

DALLAS, TEXAS U. S. A.

How to keep WILDCATTING out of Purchasing



Shown above — the new DPC-60
Single Cylinder Engine-Compressor



DPC-230 Twin-Engine Compressor

There is enough gamble involved in the oil business without carrying it into the producing equipment phase.

Ajax equipment — engines - pumps - compressors — have proven themselves through the years.

Dependable — economical — and backed with conscientious service.

You may pay a little more simply because they are worth more.

Always a full dollars value in an Ajax product — always.

SEND FOR DETAILED ILLUSTRATED TECHNICAL BULLETINS . . .

AJAX

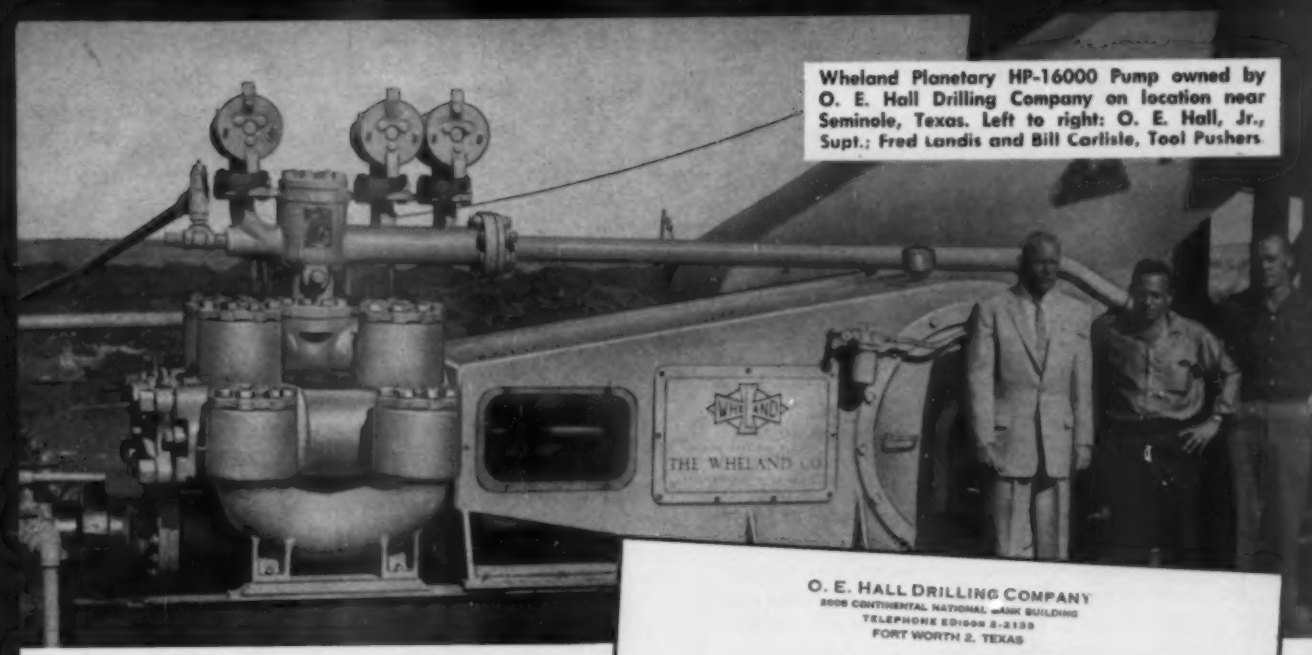
AJAX COMPRESSORS

AJAX . . . also builders of ENGINES . . . PUMPS

AJAX IRON WORKS CORRY, PENNSYLVANIA

OIL FIELD DISTRIBUTORS: The National Supply Co., Pittsburgh, Pa.

• Bethlehem Steel Co. — Supply Division, Tulsa, Oklahoma



Wheland Planetary HP-16000 Pump owned by O. E. Hall Drilling Company on location near Seminole, Texas. Left to right: O. E. Hall, Jr., Supt.; Fred Landis and Bill Carlisle, Tool Pushers

"... the pump has improved our operation ...we will be happy to recommend it."

O. E. HALL, Jr.

O. E. HALL DRILLING COMPANY
2008 CONTINENTAL NATIONAL BANK BUILDING
TELEPHONE EDISON 2-2139
FORT WORTH 2, TEXAS

February 16, 1960

The Wheland Company
Signal Mountain Road
Chattanooga, Tennessee

Mr. Gordon L. Smith, Jr.
Manager Rotary Drilling Equipment Sales

Dear Mr. Smith:

We thought you would be interested to know how pleased we are with the performance of our Wheland Planetary HP-16000 Pump. It is the smoothest running pump we have seen. The big gear reduction makes possible such a small sheave and the pump pulls very easily. We are also impressed by the compactness of the gear cartridge and the smooth performance of the new circular crosshead. In the several wells we have drilled thus far the pump has improved our operation in terms of penetration rate and savings in bits. Also has exceeded our expectations.

All of these wells have been located in West Texas. We operate our rigs throughout the Permian Basin covering a depth range of 4, 500 feet to 12, 500 feet with modern equipment.

We want to commend The Wheland Company for stepping forward with this improved design in slush pumps, and we will be happy to recommend it.

Very truly yours,

O. E. HALL DRILLING COMPANY
O. E. Hall Jr.
O. E. Hall, Jr.
Midland, Texas

WHELAND PLANETARY HP-16000 PUMP

Duplex Power Slush Pump

7 ¾"x 16", 600 HP at 65 RPM

WHELAND

ROTARY DRILLING MACHINERY

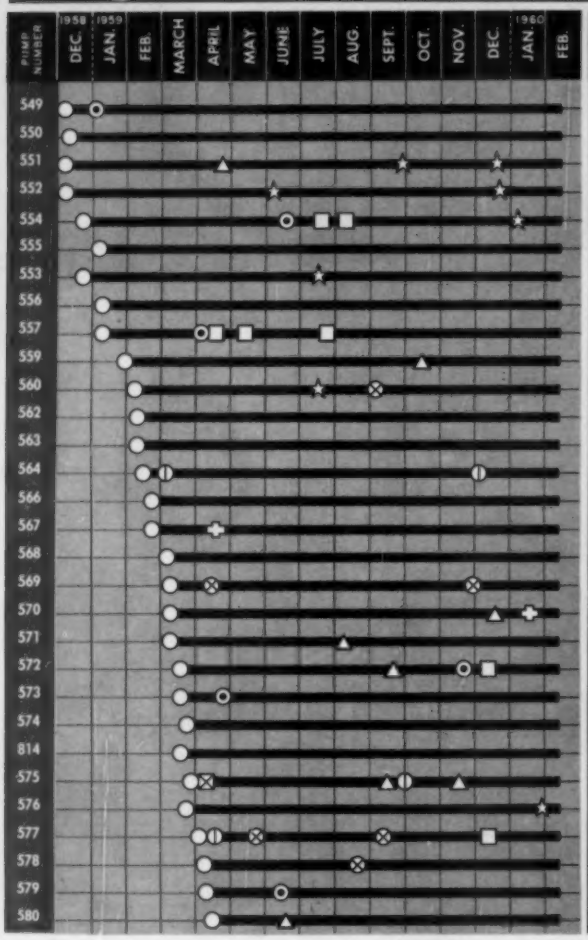
THE WHELAND COMPANY
CHATTANOOGA, TENNESSEE, U.S.A.

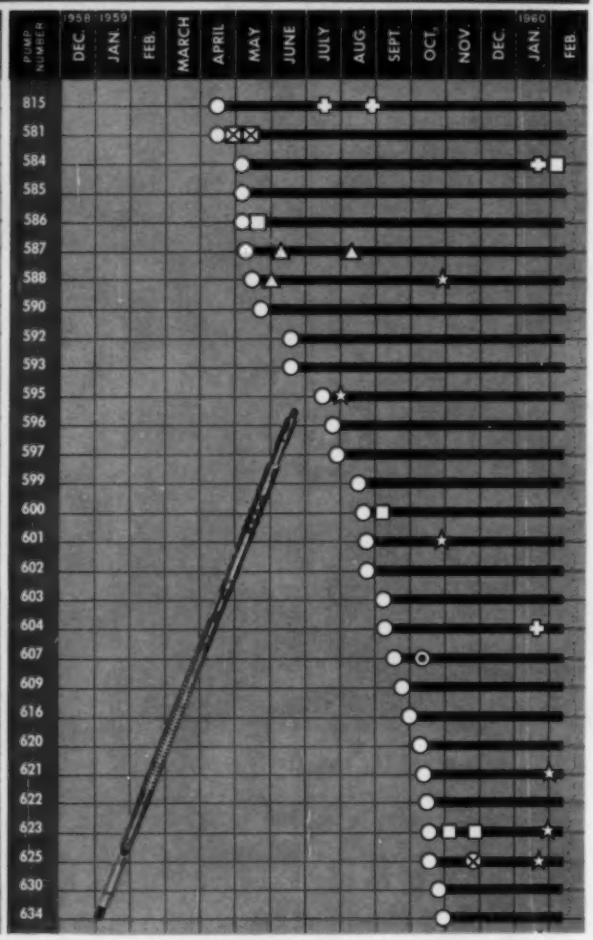
DRAW WORKS • SLUSH PUMPS • ROTARIES
CROWN BLOCKS • TRAVELING BLOCKS • SWIVELS

DOMESTIC DISTRIBUTORS: INDUSTRIAL SUPPLY COMPANY, INC.—Main Office: Wichita Falls, Texas • HOUSTON OIL FIELD MATERIAL COMPANY, INC.—Main Office: Houston, Texas.

EXPORT DISTRIBUTORS: LUCEY EXPORT CORPORATION—233 Broadway, New York 7, New York—Broad Street House, London, E. C. 2, England.

LOOK AT *Your Pump Records* TOO-





Above pump record represents 16,454 pump days of operation. 64 pulling jobs give an average of 257 pump days per pulling job. Detailed percentages below represent exact cause of pulling job.

- ○ PUMP INSTALLED
- ◉ BROKEN PART 10.9%
- □ TUBING LEAK CHECKED PUMP 18.8%
- ⊗ ROD FAILURE-CHECKED PUMP 10.9%
- △ BALL AND SEAT FAILURE 17.2%
- ◫ SANDED-UP 6.3%
- ☆ CORROSION FAILURE 21.9%
- ✪ RINGS CUT OUT 9.4%
- ⊠ FOREIGN MATERIAL IN WELL 4.6%

AVERAGE FIRST COST ON ABOVE NUTEX PUMPS $220.40

Above is one year actual day by day installation and repair of Nu-Tex pumps on several leases by one company. This record on wells 4500 to 8400 feet deep shows why they are continuing to change over to Nu-Tex. As the days go by the run average increases.

Increase production — cut cost at once!

Typical pump runs:

291 days
Repair cost $69.10 (Average for Above Pumps $43.86)
Running in low volume, hi-corrosion well at 6307 feet. Nu-Tex rings now pumping at 8428 feet. Pump No. 581 shown above.

BMW
BRADFORD MOTOR WORKS

BRADFORD MOTOR WORKS
General Office and Factory – Bradford, Pennsylvania
Branch Office and Factory Tulsa, Oklahoma
Warehouse Odessa, Texas
Excell Specialty Co. Edmonton, Alberta, Can.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

HUSKY SECURITY H9* INCREASES BIT FOOTAGE...

SPEEDS DRILLING...CUTS COSTS...INVESTIGATE!

Write today FOR H9 DATA SHEET
AND COMPLETELY NEW 1960-
1961 ALL-PRODUCTS CATALOG

*One of a Complete Family of Bits for Every Formation and Condition

Security®

ROCK BITS
REAMERS • HOLE OPENERS
STABILIZERS • CASING SCRAPERS

DRESSER INDUSTRIES INC.
OIL • GAS
CHEMICAL
ELECTRONIC

PLANTS... Dallas, Texas; Whittier, California; Manchester, England
SECURITY ENGINEERING DIVISION... 3400 W. Illinois, Dallas, Texas
EXPORT OFFICE... Post Office Box 13647, Dallas, Texas
CANADA... Security Engineering Canada, Ltd., Edmonton, Alberta, Canada
OVERSEAS... Security International C. A., Caracas, Venezuela; London, England

Armour bactericides offer low cost corrosion protection!

Bacterial analysis of untreated water supply, by Armour technical service man, indicates the presence of 27,000 or more sulfate-reducing bacteria per ml. of water. Black coloration of broth medium indicates growth of sulfate-reducing bacteria.

ARMOUR INDUSTRIAL CHEMICAL

Armour's Duomeen® compounds are serving a dual purpose for oil field operators throughout the country. These Armour chemicals not only control bacteria effectively, but reduce corrosion as much as 95% . . . at costs as low as one mil per barrel of treated water.

Using these Armour chemicals, operators realize savings by reducing costly remedial measures such as acidizing, tubing replacements, etc. Further savings are also realized by less down time and lower power costs resulting from lower injection pressures.

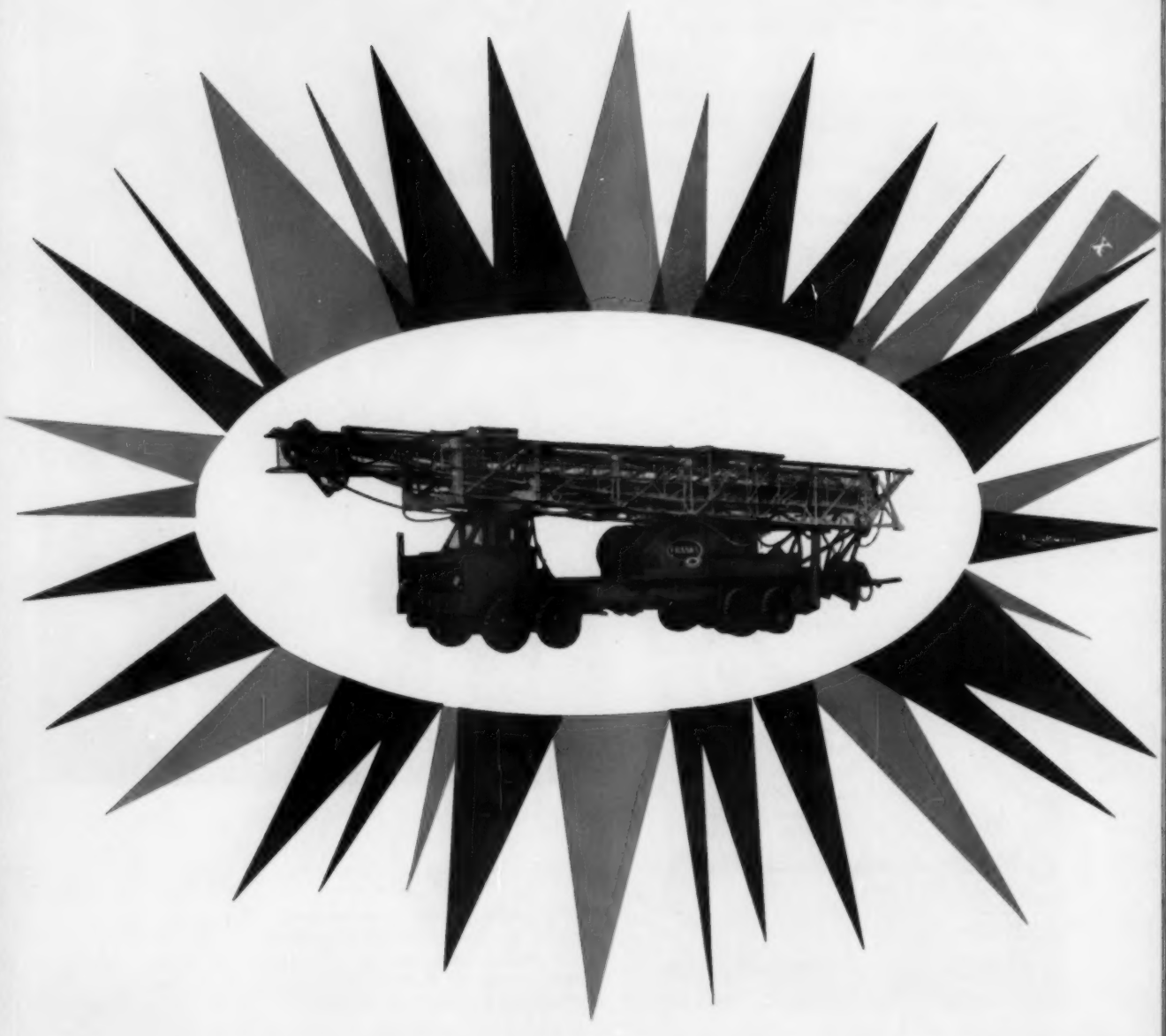
Relying on established and industry-approved tests Armour strives to help operators improve and maintain peak production efficiency. These field tests aid Armour's technical service men in making time and money saving recommendations. In the case shown here, Duomeen CD-50 is used for control of sulfate-reducing bacteria in water floods. The small inset pictures illustrate the effectiveness of this Armour chemical.

For complete detailed information on Armour's bactericide-corrosion inhibitors and other chemicals for oil production, write for the booklet, "Armour Organics for Increased Oil Production." Samples of Duomeen CD-50 and other oil production chemicals for your own testing are also available.

Using Armour recommended treatment of Duomeen CD-50, colorless broth medium shown in inset indicates complete control of sulfate-reducing bacteria after 30 days incubation.

COMPANY © *Division of Armour and Company • 110 North Wacker Drive • Chicago 6, Illinois*

FRANKS
EXPLORER
Rocket



B-14

FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

THE PETROLEUM ENGINEER, May, 1960

WORTH MORE WHEN YOU BUY IT!
WORTH MORE WHEN YOU TRADE IT!

Common sense will tell you that there is a difference in most things despite the tendency to imitate the leader. There's a difference in baseball players . . . in cooks . . . yes, even in oil well servicing units . . . although competitive units are getting to look mighty like the Franks Explorer.

Now, this **difference** is what keeps the Franks Explorer ahead of the pack. It's the difference which makes superintendents prefer Franks units on their jobs. It's the difference you feel in your pocketbook when you trade it in. The higher resale value of Franks Explorers speaks louder of this difference than any words we can dream up.

Ask the man who uses Franks!

"WORTH MORE" FEATURES

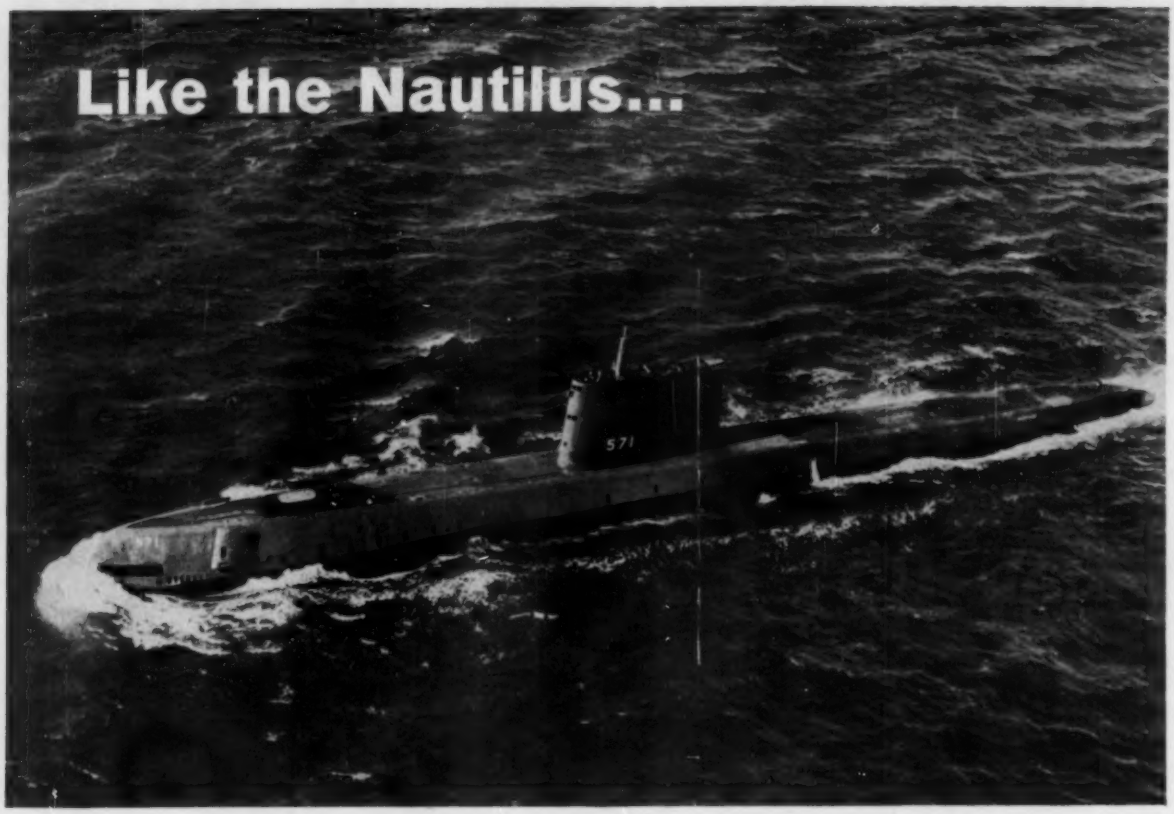
- Industrial high torque power with plenty of reserve
- Rugged duty drums . . . flanges won't spread
- Safety-view controls
- Complete package service on entire unit
- True rated capacity derricks . . . 100,000 to 275,000#
- No sag . . . no bend frame
- Safe front and rear rocker beam axle suspension
- Service proven hydratarder brakes with patented derrick tank to give maximum cooling for deepest wells
- More usable power

ON THE SPOT . . . 'ROUND THE CLOCK . . . FIELD SERVICE

And, Franks Unexcelled Factory Service the World Over Makes the Franks Explorer Worth More While You Have It!

WELL SERVICING AND DRILLING UNITS
FRANKS
DIVISION OF
CABOT
PAMPA, TEXAS

. . . manufacturers of the most imitated units in the field today!



Rectorheads are *"Sealed With Steel"*

Rector pioneered the welded seal principle in casing heads . . . the same principle of welding that is used in the construction of today's atomic submarine "Nautilus," built to withstand extreme temperature variants, torque, and tremendous pressure as it cruises the ocean depths.

Rector's welded seal plus API Ring Gasket, never requires replacement or maintenance. Well or "Frac" pressure cannot be transmitted to the slips where hydraulic pressure can collapse or crush pipe. Rector casing heads are built to withstand fire, shock, freezing temperature and highest well-head pressures. The soundness and complete efficiency of application and service of the Rector welded seal has been proven in over 100,000 trouble free field installations.

RECTORHEADS are available in sizes through 20". See your Rector representative or order from your favorite supply store.

Rector

Well Equipment Co., Inc.

Making the Oil Industry Safer!

1100 North Commerce, Fort Worth, Texas
Houston Plant: 2215 Commerce Street

EXPORT REPRESENTATIVES: Continental-Emsco Co., Mid-Continent Supply Co., Oilwell Division of United States Steel Corporation

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Loading of this portable drill rig was started at 6:30 A.M., and Macks are ready to haul it to new location in Cadiz Field, Live Oak County, Texas—32 rugged cross-country miles away.

ON SCHEDULE—REGARDLESS

"Here's why we operate with the best equipment we can buy," says H. L. (Brownie) Choate, veteran oil field trucker of Alice, Texas.

"One thing you can't afford in this fast-moving business is on-the-job truck breakdowns or bogdowns . . . even though you have to make your drilling equipment move on schedule, never knowing exactly what you're going to run into, or what your trucks will be called on to do.

"On-the-job breakdowns have become a thing of the past since we made Macks the backbone of our fleet. And as for bogging down, experience has convinced us that Mack's four-wheel drive Balanced Bogie with Power Divider will pull through anything that we, or anyone else, will run into in this business."

Brownie Choate and his experienced truck pusher "Boots" Niehaus know their job . . . and their Macks. They expect rugged working conditions, and they're ready for them with trucks that are built to take on the roughest, toughest jobs in the oil fields.

Your Mack branch or distributor will show you why Mack trucks can save you plenty in terms of downtime, delays and headaches. Mack Trucks, Inc., Plainfield, New Jersey. In Canada: Mack Trucks of Canada, Ltd., Toronto, Ontario.

MACK
FIRST NAME FOR
TRUCKS

At new drilling site, Macks go to work setting up rig platform. Terrain proved unexpectedly bad but the trucks were there on schedule. On-the-job performance comparisions switched H. L. Choate to Macks.

New rig platform nearing completion as Macks spot heavy platform sections. Jobs like these call for fast, sure teamwork between trucks and crews. This job was cleaned up in 6½ hours . . . thanks to capable equipment.

Baker's New Snap-Set Duals

—the packers that are bringing single-zone control and simplicity to dual completions

A Baker dual-string completion approaches the control and simplicity (and the flexibility) of a single-zone completion. What makes this possible? Mainly the development of better upper retrievable packers—Baker's new Snap-Set Dual Packers. Operators all across the country are commenting on their impressive performance.

What makes a good dual-string packer? Several things, starting with the ability to (a) set and unset readily and repeatedly; (b) pack off and retrieve easily; (c) hold a dependable packoff even when pressures and temperatures are high.

Do Baker's new dual packers do these things? They do. This is easy to understand when you consider Baker's vast experience with high performance retrievable squeeze packers. The Baker Full-Bore Cementer, for instance, has seen action in thousands of successful high pressure cementing, frac, and testing operations. This squeeze packer experience has made important contributions to the design of these new dual production packers.

That's only a brief look at the story of these remarkable packers. A few more of the interesting facts are spelled out by the pictures and text below. For a complete fill-in on Baker snap-set duals and the hookups they're used in, consult Baker's field staffs and send for literature.

FACTS ON PLANNING DUAL-STRING COMPLETIONS

Baker field staffs have all the latest facts and figures on Baker's intensive continuing study of dual-string completions. They will welcome your inquiries. We will also be glad to send you the latest literature. Please write Baker Oil Tools, Inc., P.O. Box 2274, Terminal Annex, Los Angeles 54, California.

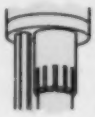
TWO BASIC MODELS. Model J (Product 756-J) is long-string set. Model K (Product 756-K) is short-string set. Both come with or without hold-down buttons (double or single grip). The pictures show single-grip Model J.

WHAT MAKES A GOOD DUAL PACKER?

The text above tells some of the things that are important. Here are a few more of the facts, starting with big unrestricted bores. Big bores are important because they permit you to run instruments and workover tools. These are probably the largest bores it's possible to design into a dual packer. For instance, a Baker dual packer for 7" casing is full-opening for two strings of 2⅜" tubing.

POSITIVE PACKOFF AND RELEASE

This three-element packing element design achieves a positive and lasting packoff with minimum set-down weight. It also simplifies release when you want to reposition or retrieve. What makes this possible is that the design prevents packing element extrusion without using the conventional metallic back-up rings that sometimes stick to the casing and defeat retrievability.



WHY SNAP-SETTING IS IMPORTANT

This simple snap-latch is what makes a Baker dual packer so easy to set and unset repeatedly. There are no one-shot shear pins. There's no ball dropping, no pressuring, no rotation. Just set down minimum weight to set packer, and pick up to release. This simplifies spacing out and enables you to test packers before displacement.

YOU CAN DISPLACE WHILE FLANGED UP

Using a side door completion valve, or sleeve valve, or other method, you can displace mud and wash in both zones with well head flanged up and under complete control.

BAKER

SNAP-SET DUAL PACKERS

BAKER OIL TOOLS, INC. HOUSTON • LOS ANGELES • NEW YORK

WORLD'S DEEPEST ULTRA-SLIM HOLE IS ULTRA HOT

Floyd Newlin • **J. E. Kastrop**
Penrod Drilling Company, Dallas, Texas — *The Petroleum Engineer, Dallas, Texas*

At 20,603 ft where bottom-hole temperatures measured 456 F, the last 3¾-in. bit was pulled from Hunt Oil Company's deep wildcat in Webb County, Texas, not far from Mexico

A new slim hole record has been set by Penrod Drilling Company's Rig No. 4 almost four miles below this location. Better-than-expected drilling pushed a 3¾-in. bit to a total depth of 20,603 ft where temperatures measured 456 F (over twice that of boiling water).

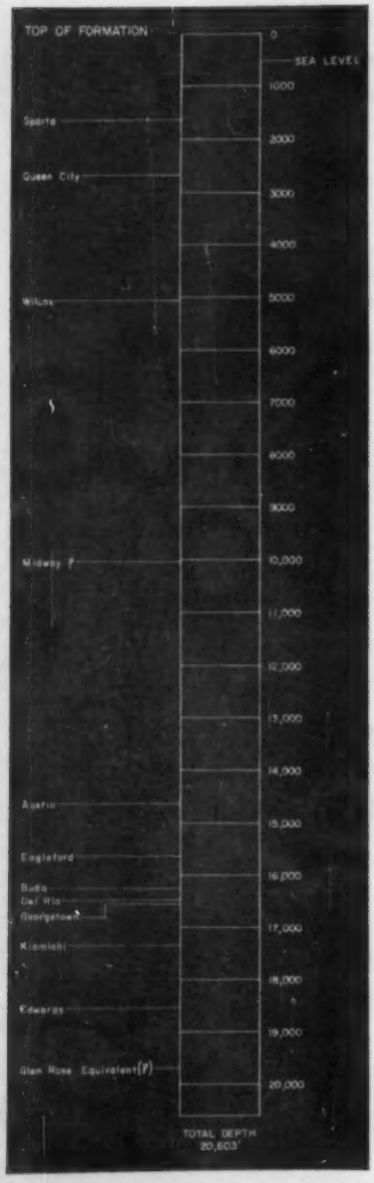
"WILD AND INTERESTING" is the way Warren Gray, chief geologist for Hunt Oil Company of Dallas, described its deep wildcat, the J. O. Walker No. 1. Located some 35 miles northeast of Laredo, Texas, this unusual well was drilled to a total depth of 20,603 ft by Penrod Drilling Company's Rig No. 4.

Depth alone did not set the J. O. Walker No. 1 apart from other super-deep holes. But, two drilling barriers did. The last 1419 ft were drilled with 3¾-in. bits through a super-hot section where bottom-hole temperatures measured 456 F. Experienced oil men can quickly visualize a host of difficulties under such conditions, but no unusual drilling problems were ever encountered. A well-engineered mud program, good drilling equipment, experienced personnel, and particularly good hydraulics are some of the factors attributed to the drilling success. In fact, other than a gas kick and two minor fishing jobs, the well could be described as normal drilling. Even in the 3¾ in. hole, drilling rates frequently exceeded 100 ft per day.

Bit No. 1 broke the surface on July 3, 1959. Just 246 days later on March 5, 1960, bit No. 94, a 3¾-in. diamond bit, was the last to be pulled from the well after reaching a total depth of 20,603 ft. Penrod's giant power Rig 4 was moved off seven days later after plugging back to 9925 ft. At this writing, the J. O. Walker No. 1 is still undergoing testing with a smaller rig in the zones above 9000 ft.

Data on Structure Is Scarce

Other than seismic information, not much is known about the deep-seated structures in this region. To the south of the Hunt Oil Company wildcat is the Pescadito Dome, a prominent geologic structure first mapped in the early 1930's by Dr. E. H. Sellards of The University of Texas. Since that time, exploration has continued, but it was not until 1950 that a deep test was drilled . . . and it was halted at 13,704 ft because of mechanical difficulties caused by high subsurface temperatures. Seven years later, Ginther, Warren and Ginther of Houston, drilled its O. W. Killam No. 1 to a depth of 15,107 ft to penetrate the giant salt plug (*The Petroleum Engineer*, October 1957, pg. B-21). Although a temperature of 460 F was measured at 14,552 ft, there was some doubt as to the accuracy of measurement at that time. Since, however, bottom-hole temperature bombs have been improved and reliability of accuracy increased.



Formation log of Hunt Oil Company's J. O. Walker No. 1 in Webb County, Texas. Below the Edwards, objective of this wildcat, it is difficult to determine the lithologic age of the formations, thus the question mark after the Glen Rose equivalent. FIG. 1.

Again, in the fall of 1958, Ginther, Warren and Company drilled another deep Pescadito test to 19,503 ft to set a deep slim-hole record. A 4 9/16-in. hole was drilled from 16,536 ft to total depth, and in this well, the highest temperature recorded was 420 F. More was learned of the geology of the subsurface as well as of drilling practices. These are discussed in detail in *The Petroleum Engineer*, March 1959, pg. B-30.

Something of the stratigraphy of the region had now been established for a considerable depth. But, the Hunt Oil Company wildcat was removed much to the north of the Pescadito Dome and, other than the influence of abnormal temperatures characteristic of this region, the structure explored was not connected with or influenced by the Pescadito structure, reported to be some 50 square miles in area with a closure of about 6000 ft.

Fig. 1 is a log of formations penetrated by the J. O. Walker No. 1. Geologists believe the well penetrated every formation anticipated in the section as known from further up-dip wells. Objective of this well was the Edwards lime, which was topped at about 18,500 ft. Well over 1000 ft of Edwards was drilled, below which the geologic age of the formations are difficult to determine, although believed to be equivalent to the Glen Rose.

The Hunt well was located on the flank of a seismic anomoly completely separate from the Pescadito structure, and to date there is no evidence the seismic anomoly is a salt dome. But, due to the relative down-dip regional position of the J. O. Walker No. 1, each of the geologic units penetrated was expanded relatively uniform in thickness.

Summary of Drilling Equipment

Penrod Drilling Company's Rig No. 4 is in the deep drilling class. Rated input of the drawworks is 1600 hp, putting it in the 20,000 ft drilling depth bracket with 4½-in. drill pipe. Three diesel engines power the drawworks. Each engine is a V-12 with an intermittent output rating of 520 hp at 1300 rpm. Combined, they are capable of developing 1320 continuous hp and over 1500 hp for hoisting.

Mud Pumps

Two mud circulating pumps gave the rig its hydraulic horsepower punch. One of the pumps, an 8-in. by 18-in., has an input rating of 1000 hp and is V-belt driven from the drawworks engine compound. The second pump is separately powered by a V-12 diesel engine rated at 500 continuous hp and 575 intermittent hp. Size of this pump is 7¾-in. by 18-in. A third pump, which serves as a standby and mixing pump, is also separately driven and skid-mounted. It is 7½-in. by 14-in. and powered by a diesel engine rated at 300 continuous hp output.

Mast and Substructure

The 142-ft cantilever mast has a rated load capacity of 1,000,000 lb resting on an 18-ft substructure.

Although Rig No. 4 is capable of drilling to 20,000 ft with 4½-in. drill pipe, casing program problems met in the J. O. Walker No. 1 made it necessary to use a tapered drill string at total depth as indicated in Fig. 2.

Casing Program

The original casing program was designed for 300 ft of 20-in. surface casing; 6500 ft of 13⅜-in. casing; 13,000 ft of 9⅝-in. casing and 7-in. to 18,000 ft. Due to a gas kick at 10,338 ft, and a lost circulation problem in this zone which would not permit mud weights to be increased above 14 lb per gal, the casing program was altered and the 9⅝-in. casing was set to 10,333 ft. The entire casing program is shown graphically at the right of the drilling time chart in Fig. 3.

A 7-in. liner was then set at 14,791 ft and hung inside the 9⅝-in. casing at 10,126 ft. Below this depth, a 4½-in. liner was hung inside the 7-in. from 14,619 ft and cemented at 18,563 ft. At the time the 4½-in. liner was set, total depth was 19,184 ft, but the reason for not setting on bottom was for testing purposes.

DRILLING HIGHLIGHTS

Most of the pertinent drilling data are presented in Fig. 3 which includes the drilling-time chart, bit record, casing and cement record, mud data, and drilling conditions. Some of the more significant events are reported below by intervals to total depth.

Surface to 6478 ft.

A 26-in. hole was drilled to 301 ft and 20-in. surface casing was set to 300 ft. And, 28 days after drilling out of the 20-in. casing, the 17½-in. hole reached 6478 ft and 13⅜-in. casing

was set to 6475 ft. The hole from 300 ft to 6478 ft was drilled and reamed with eleven 17½-in. rock bits, fourteen 12¼-in. rock bits and one 17½-in. reamer.

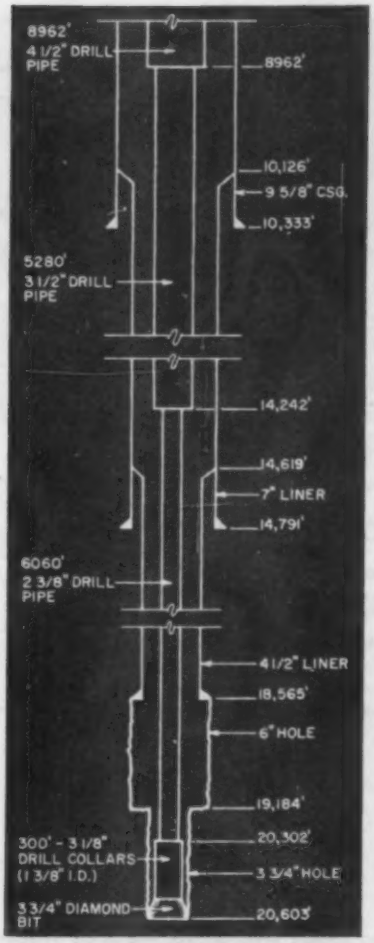
Interval from 6478 to 10,338 ft.

Only 23 days were required to drill a 12¼-in. hole from 6478 ft to 10,338 ft, using 17 rock bits. At this latter depth, the well began to kick while drilling ahead with 13.0 lb per gal mud. When mud weight was raised to 15.0 lb per gal, circulation was lost. The hole was finally controlled with 14.0 lb per gal mud, but 25 days were lost in getting back to bottom, circulating and conditioning the well.

Because of this formation problem, it was decided to set 9⅝-in. casing at this depth to case off the trouble zone, rather than risk drilling to programmed-depth as originally planned. A 9⅝-in. liner was cemented to 10,333 ft, and 14 days were spent in logging, circulating and conditioning the hole for logging and running the casing. Five-inch OD drill pipe was used in drilling the 12¼-in. hole to 10,338 ft. Bottom-hole temperature measured at 10,178 ft recorded 225 F.

Interval from 10,338 to 14,791 ft.

This interval was drilled with 32 8⅜-in. rock bits in 50 drilling days. Two days were spent in circulating and conditioning the hole as a result of gas-cut mud, and logging to 13,822 ft. At 14,791 ft, it was decided to run a 7-in. liner. Temperature at this depth measured 312 F. The liner was bottomed at this depth. However, the previous 9⅝-in. liner was altered to extend all the way up to the surface rather than part way. Logging, changing the 9⅝-in. liner, conditioning the hole, and cementing the 7-in. liner required 16 days. Of these, six were spent in fishing out drill pipe rubbers which came off the drill pipe due to high temperature while drilling out the cement plug in the 7-in. liner. The abnormally high bottom-hole temperature made it difficult to keep the drill pipe protectors on the drill string, and their use was discontinued.



Subsurface mechanical picture at total depth. While drilling bottom section, 106 gal per minute of mud were circulated at 2400 psi pump discharge pressure. FIG. 2.

Interval from 14,791 to 19,184 ft.

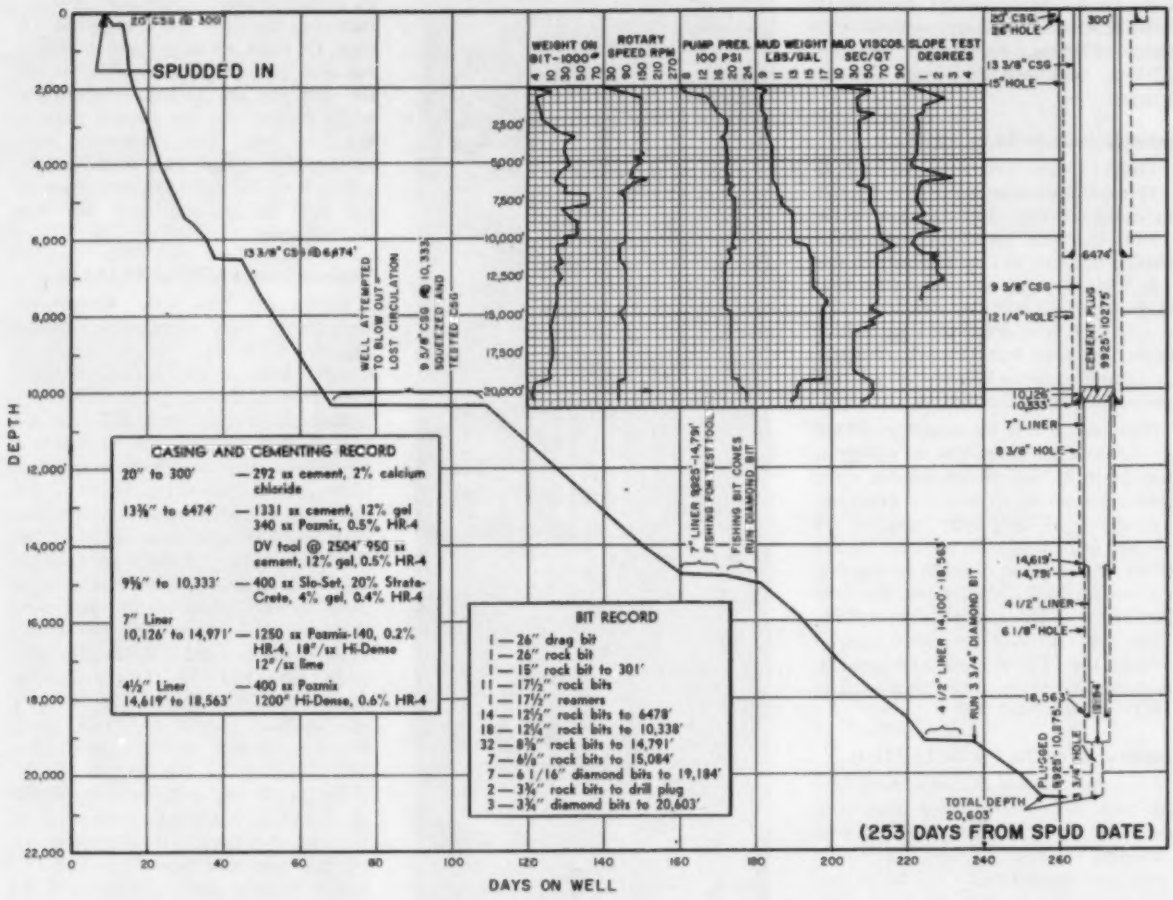
Below the 7-in. liner, several bit sizes in the 6-in. range were used to drill from 14,791 ft to 19,184 ft. A 6⅛-in. hole, a 6 3/32-in. hole, a 6 1/16-in. hole, and a 6-in. hole were drilled with 6 rock bits and 7 diamond bits. Drilling time for this interval was 49 drilling days, two days were spent in logging at 19,041 ft. Six rock bits drilled from 14,791 to 15,084 ft where diamond bits were first used. In the 6-in. sizes, average footage per rock bit was 47 ft. One bit was used almost exclusively in drilling up the drill pipe protector rubbers and junk. Seven diamond bits were used in drilling the hole from 15,084 to 19,184 ft for an average per bit of 585.7 ft. At 19,184 ft, it was decided to run a 4½-in. liner. But, since it was necessary to test the lower section of this section of the well, the 4½-in. liner was bottomed at 18,563 ft. Nine days were spent in running the liner and attempting to test the open hole from 18,563 to 19,184 ft. Temperature measurements recorded the following: at 13,816 ft — 290 F; at 14,606 ft — 312 F; at 17,876 ft — 384 F; and at 19,036 ft — 424 F.

Interval from 19,184 ft to 20,603 ft.

Starting at 19,184 ft, a 3¾-in. hole was drilled to total depth, 20,603 ft, in 14 drilling days with three diamond bits. Average drilling time was 101 ft per day, and average footage was 473 ft per bit. Three days were spent drill-stem testing at 19,932 ft. After reaching total depth, logs were run and a test of the open hole was attempted. Seven days after reaching total depth, the well was plugged back to 9925 ft and the rig released. Bottom-hole temperature at 20,571 ft measured 456 F. Fig. 4 plots the temperature gradient, compared to normal and to that recorded in the Ginther, Warren and Ginther O. W. Killam No. 1.

Mud weight had been cut back at the beginning of this interval from 18.0 to 13.0 lb per gal. It is suspected that the reduction in mud density which greatly reduced the hydrostatic head pressure at the bit was a factor in the good drilling experienced in the small hole.

Part of the team that pushed a small hole to record depths through extreme heat. Standing, left to right: Bill Hensley, Baroid; H. C. Gilbert, toolpusher; H. B. Cagle, day driller; V. E. Zell; A. J. Desormeaux; I. A. Ganey; C. J. Downs; and C. D. Pryor. Kneeling, left to right: Cleo Duke, Baroid; J. Waggoner, evening driller; E. G. Ward; G. D. McElfresh; J. B. Wright; and Lawrence Mann. Not shown are: L. R. Murphy, morning driller; W. R. Bopp; G. D. Tinsley; R. L. Cleveland; and J. R. Richey.


SPUDDED IN
20" CSG @ 300'
13 3/8" CSG @ 6474'
WELL ATTEMPTED TO BLOW OUT — LOST CIRCULATION
9 5/8" CSG @ 10,333' SQUEEZED AND TESTED CSG
7" LINER 9925'-14,791' FISHING FOR TEST TOOL
FISHING BIT CONES RUN DIAMOND BIT
4 1/2" LINER 14,100'-18,563' RUN 3 3/4" DIAMOND BIT
PLUGGED 9925'-10,275'
CEMENT PLUG 9925-10275
TOTAL DEPTH 20,603'
(253 DAYS FROM SPUD DATE)
DEPTH
DAYS ON WELL
WEIGHT ON BIT-1000#
ROTARY SPEED RPM
PUMP PRES. 100 PSI
MUD WEIGHT LBS/GAL
MUD VISCOS. SEC/QT
SLOPE TEST DEGREES
20" CSG. 26" HOLE
13 3/8" CSG
15" HOLE
9 5/8" CSG
12 1/4" HOLE
7" LINER
8 3/8" HOLE
4 1/2" LINER
6 1/8" HOLE
3 3/4" HOLE
CASING AND CEMENTING RECORD
20" to 300' — 292 sx cement, 2% calcium chloride
13⅜" to 6474' — 1331 sx cement, 12% gel 340 sx Pozmix, 0.5% HR-4
DV tool @ 2504' 950 sx cement, 12% gel, 0.5% HR-4
9⅝" to 10,333' — 400 sx Slo-Set, 20% Strata-Crete, 4% gel, 0.4% HR-4
7" Liner 10,126' to 14,971' — 1250 sx Pozmix-140, 0.2% HR-4, 18#/sx Hi-Dense 12#/sx lime
4½" Liner 14,619' to 18,563' — 400 sx Pozmix 1200# Hi-Dense, 0.6% HR-4
BIT RECORD
1 — 26" drag bit
1 — 26" rock bit
1 — 15" rock bit to 301'
11 — 17½" rock bits
1 — 17½" reamers
14 — 12¼" rock bits to 6478'
18 — 12¼" rock bits to 10,338'
32 — 8⅜" rock bits to 14,791'
7 — 6⅛" rock bits to 15,084'
7 — 6 1/16" diamond bits to 19,184'
2 — 3¾" rock bits to drill plug
3 — 3¾" diamond bits to 20,603'

Graphic picture of drilling and casing program for the J. O. Walker No. 1. Rig No. 4 spudded in on the ninth day after moving in and rigging up. A total of 246 days was spent from date of spud to reaching total depth. The rig was released 7 days later. FIG. 3.

Good Drilling in Spite Of Obstacles

Although relatively high mud weights were required, and high bottom-hole pressures existed, and abnormally high formation temperatures were present, along with extremely small hole sizes below 14,791 ft, the amount of lost time spent in fishing was small. Six days out of 253 days were spent in fishing out lost rubber drill pipe protectors which came off the pipe while drilling inside the 7-in. liner under 312 F temperature. This was the only time spent in fishing.

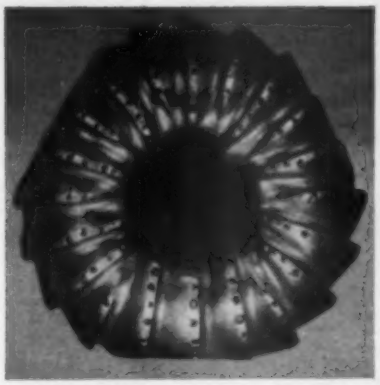
Eighty-six days, or 34 percent of the 253 days, were spent in running casing, cementing, logging, testing, combatting gas kicks and lost circulation. If higher mud weights could have been used in drilling the well from the bottom of the 13⅜-in. casing to 13,000 ft without setting the 9⅝-in. casing, a considerable saving in time, mud and casing could have been realized. In the 86 days lost, 25 of them were spent at 10,338 ft when the well would alternately kick and lose circulation between 13.0 and 15.0 lb per gal mud. The well was finally brought under control after working back to bottom with a mud weight of 14.0 lb per gal. An additional 14 days were spent in running logs, running and cementing a liner. Excessive time used in these operations was brought about by the "touchy" condition of the hole.

Use of diamond bits started at 15,084 ft and continued to total depth. In all, ten diamond bits were used. A summary of the diamond bit performance is shown in Table 1. The complete bit record is given in Fig. 3. By considering the salvage value of the 10 diamond bits used, the average bit cost per foot of hole drilled by these 10 bits was $3.67 per ft. In the interval drilled by these bits, only 10 trips were made. The discrepancy in feet per day against feet per hour showed in Table 1 is that the former is based on drilling days,

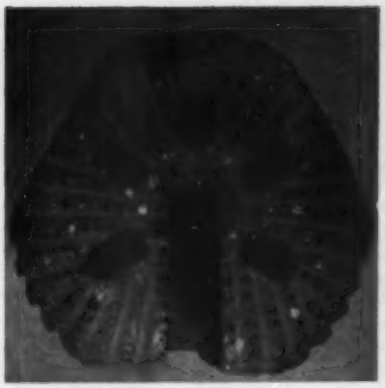
TABLE 1. Diamond Bit Data From Hunt Oil Company's J. O. Walker No. 1. Average Bit Cost: $3.67/ft.

Bit No.	Size	Depth out	Feet drilled	Hours drilled	Ft per hour	Bit price	Salvage	Net bit cost
85	6 3/16	15,730	646	138.7	4.6	3950	1532	2418
86	6 1/16	16,306	576	100.0	5.8	3831	1546	2285
87	6 1/16	16,783	477	99.0	4.8	3870	1097	2773
88	6 1/16	16,918	135	64.0	2.1	3900	2616	1284
89	6 1/16	17,913	995	198.5	5.0	3951	1669	2282
90	6 1/16	19,041	1128	224.7	5.0	3877	1047	2830
91	6	19,184	143	33.0	4.3	3700	778	2922
92	3¾	19,443	259	46.3	5.6	1945	640	1305
93	3¾	19,932	489	104.5	4.7	1855	809	1046
94	3¾	20,603	671	137.0	4.9	1651	555	1096
TOTALS			5519	1145.7	Av. 4.8	32,530	12,289	20,241

Courtesy Hycalog, Inc.



Bit No. 94, the last run in the J. O. Walker No. 1. It is a 3¾in. custom-made diamond bit.



Used 6 1/16-in. diamond bit as it looked after drilling 1128 ft of hole from 17,913 to 19,041 ft. Bit No. 90.

Bit No. 90 when new. Same diamond bit shown in previous photograph with patented design.

Photos Courtesy Hycalog, Inc.

including trips, etc., while feet per hour are calculated on actual drilling time spent on bottom.

PLANNED MUD PROGRAM FOLLOWED

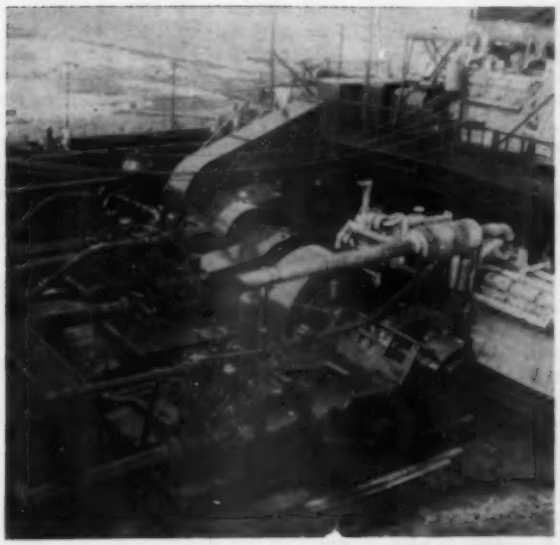
Experience on the wells drilled for Brewster and Bartle — Sunray, and Ginther, Warren and Ginther et al, in Webb County had shown that unusually high temperatures were to be expected. Temperatures above 400 F at a depth of 15,000 ft had been reported.[1,2] High-pressure gas, salt water, anhydrite and rock salt had to be considered and loss of circulation appeared likely. With these potential difficulties in mind, a mud program was planned that would provide adaptability to whatever changes became necessary as problems developed.

A gypsum-treated mud was recommended, with ferrochrome lignosulfonate (FCL) to control flow properties and to aid in the control of filtration properties. Sodium carboxymethyl cellulose (CMC) would be used to reduce filtration. A water-soluble oxyethylated phenol (DMS) was to be added as an aid in the control of flow properties after the soft shale section had been drilled. When the bottom-hole temperature reached 350 F, or at a time when filtration control became difficult, the calcium ion was to be removed from the filtrate; salt added, and lignite used for filtration control to total depth.

Laboratory tests had shown that the lignite-surfactant treatment afforded stable filtration properties at temperatures as high as 450 F.[3] If differential sticking was indicated, an oil-soluble surfactant was to be added to minimize this danger. Control of flow properties would be directed to the maintenance of low yield point and plastic viscosity to minimize danger of loss of circulation. A centrifuge would be utilized to discard drilled solids and conserve barite.

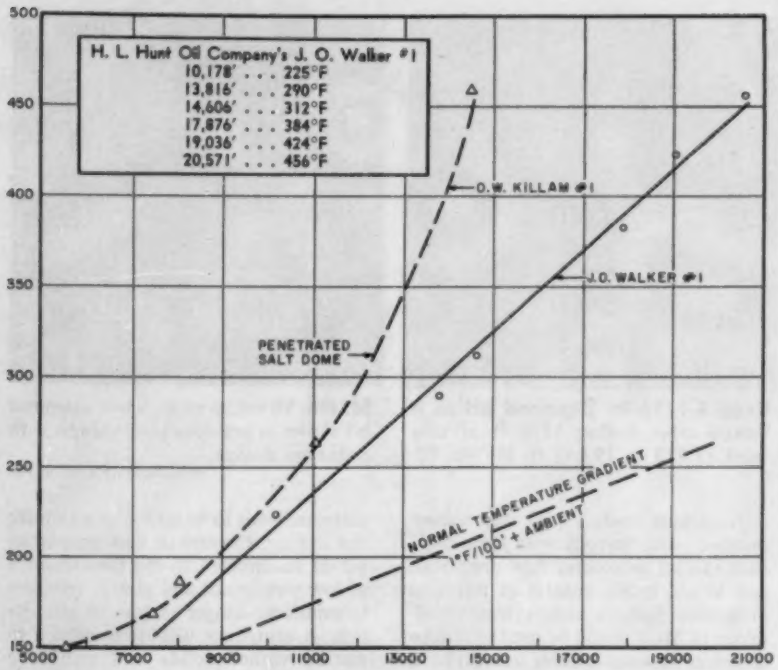
Surface Hole

The well was spudded in with water and bentonite. Beginning at a depth of about 1000 ft, the native shale mud was treated with small amounts of caustic-quebracho and FCL to insure a gage hole for a satisfactory cement job on the surface casing. Surface casing (13⅜ in.) was set at 6467 ft. Materials used to that depth are listed in Table 2. Properties of the mud at the time casing was run were: Weight



Hydraulic powerhouse of Penrod's Rig 4. No. 2 pump at right is separately driven. With 4½-in. lines, this 7¾-in. by 18-in. pump circulated 106 gal per minute of mud at total depth of 20,603 ft. Discharge pressure was 2400 psi.

Mud supervision was a continuing chore, ably handled by Cleo Duke, of Baroid, shown in the field mud laboratory set up for this unusual well.



Temperature gradient of J. O. Walker No. 1 compared to normal gradient and that of Ginther, Warren and Ginther's O. W. Killam No. 1 drilled into the Pescadito salt dome in 1957. Gradient for latest Pescadito well, drilled to 19,503 ft in 1959, almost paralleled that of the J. O. Walker No. 1. FIG. 4.

10.7 lb per gal; funnel viscosity 45 sec; gels 0-0 grams; plastic viscosity 20 centipoise; yield point 19 lb per 100 sq ft; filtrate 6 cc.

TABLE 2. Materials Used in Native Shale Mud.
Depth, ft: 0 to 6400, 29 days,
Total cost: $6800.

	Tons
Bentonite	5
Caustic soda	3
FCL	7
Quebracho	7
Fine mica and nuthulls	2

Gypsum-Treated Mud

A graphic record of mud properties from 6400 ft to total depth, at 100 ft intervals, is given in Fig. 5.

The mud was converted to a gypsum-treated mud in the casing by adding 5.5 lb per bbl gypsum, 5.5 lb per bbl ferrochrome lignosulfonate and 0.8 lb per bbl caustic soda. Mud properties after conversion were: Weight 10.3 lb per gal; funnel viscosity 57 sec; gels 0-0 grams; plastic viscosity 25 centipoise; yield point 5 lb per 100 sq ft; filtrate 8 cc; calcium ion 1080 ppm. A degasser was installed for the removal of entrained gas if necessary. Special emphasis was placed on keeping the yield point low in order to minimize the possibility of loss of circulation.

Field mud lab. Because aging tests under elevated temperatures and other special tests would be needed for assured good mud performance, a field laboratory was placed on the location. Aging tests, high-temperature, high-pressure filtration tests, and pilot tests were conducted to indicate mud performance under existing bottom-hole conditions and also under anticipated conditions. Fig. 2 shows some of the special mud-testing equipment in use in the field laboratory.

Gas kick encountered. At approximately 8700 ft, gas pressures were encountered which required a 12.8 lb per gal mud to prevent the entry of gas into the bore hole. At 10,334 ft, gas cutting occurred and mud weight was raised to 13.6 lb per gal without stopping the entry of gas. Further increases in weight resulted in loss of returns.

Continued attempts were made to stop loss of mud and to prevent the entry of gas until circulation was regained with a mud weighing 14.0 lb per gal. A 9⅝-in. liner was set at 10,333 ft. Mud properties at this depth were: weight 14.0 lb per gal; funnel viscosity 55 sec; gels 0-5 grams; plastic viscosity 41 centipoise; yield point 15 lb per 100 sq ft; filtrate 3.6 cc; 1640 ppm calcium; oil 9 percent; solids 26 percent. Materials used in the gypsum-treated mud while drilling from 6467 ft to 10,334 ft are listed in Table 3, column A. Column B, Table 3 shows the materials used in controlling gas pressure and loss of circulation at 10,334 ft.

A centrifuge was installed to effect the economical removal of drilled solids and the recovery of barite. Weight was increased to 15.5 lb per gal at about 11,000 ft. Average daily treatment while drilling in the interval 6467 ft to 12,000 ft were: 0.5 lb per bbl gypsum, 1.5 lb per bbl FCL and 0.4 lb per bbl caustic soda. Materials used in drilling from 10,334 to 12,000 ft are listed in Table 3, column C.

TABLE 3. Materials Used in Gypsum-Treated Mud.

	A	B	C
Depth, ft:	6400 to 10,334	Lost circulation	10,334 to 12,000
	26 days	25 days	29 days
Total cost	$27,500	$74,400	$28,000
	Tons	Tons	Tons
Barite	300	884	400
Bentonite	2	25	3
Clay	5	4	1
Caustic soda	5	2	1
FCL	17	18	13
CMC	1	3	1
Gypsum	12	9	1
Fine mica and nut hulls	8		13
Lost circulation materials		50	
Diesel oil	327 bbl		255 bbl

Gypsum-Surfactant Mud

As an aid in the control of filtration and flow properties of the mud, a water-soluble surfactant (an oxyethylated phenol, DMS) was added to the mud while drilling at 12,000 ft. The mud was treated initially with 4 lb per bbl of DMS and the concentration was maintained at about 2 lb per bbl thereafter. Mud properties after addition of DMS were: weight 15.5 lb per gal; viscosity 56 sec; gels 0-5 grams; plastic viscosity 41 centipoise; yield point 13 lb per 100 sq ft; filtrate 2.8 cc; calcium 1680 ppm; oil 10 percent; solids 28 percent.

An electrical log was run at 13,811 ft and a bottom-hole temperature of 290 F was recorded. Another log was run at 14,606 ft and the bottom-hole temperature was reported to be 312 F. At a depth of 14,791 ft a 7-in. liner was set. Mud materials used in the gypsum-surfactant mud are shown in Table 4. Average daily treatments in the interval 12,000 ft to 14,791 ft were: 1.0 lb per bbl FCL, 0.3 lb per bbl gypsum, 0.1 lb per bbl DMS and 0.05 lb per bbl CMC.

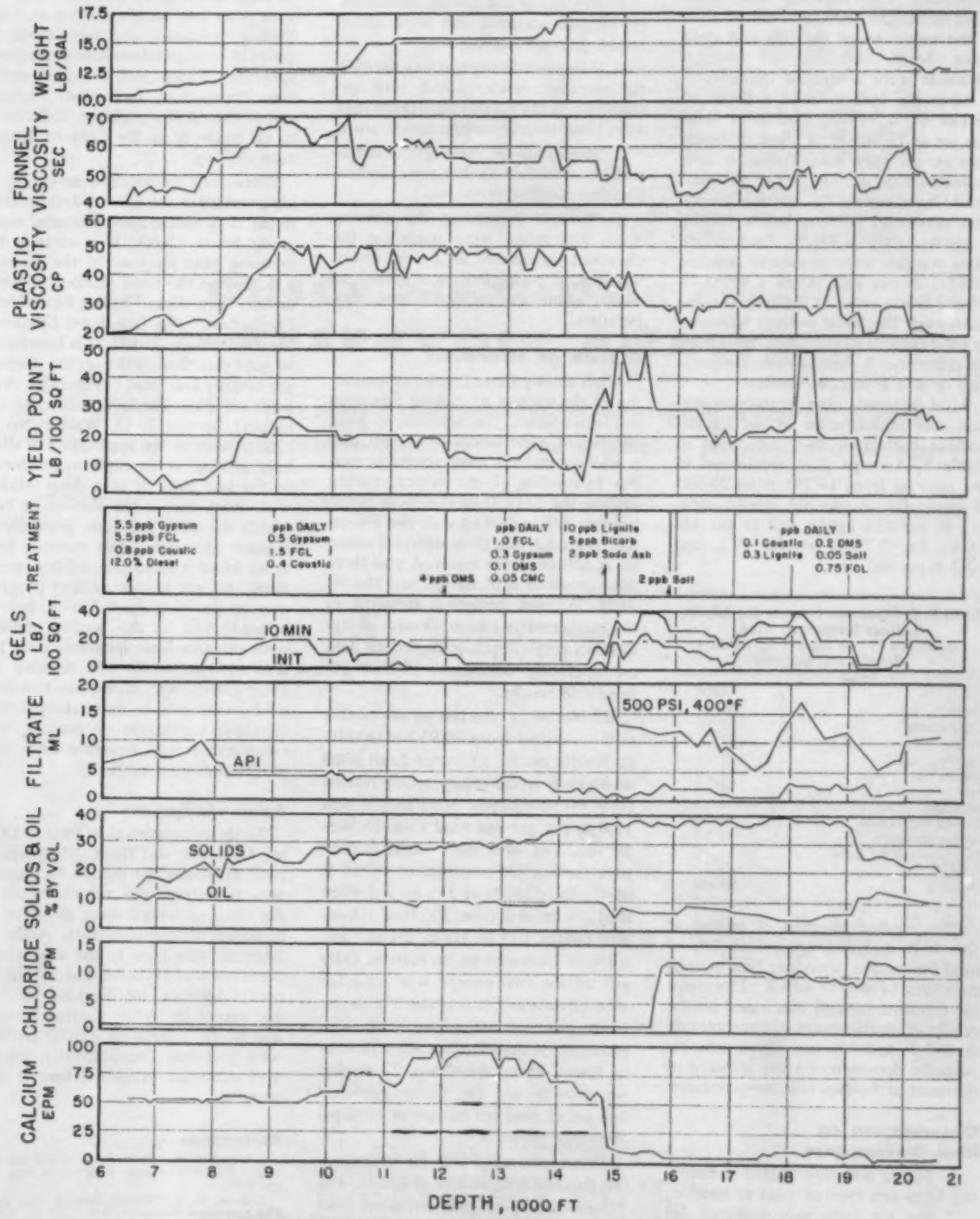
TABLE 4. Mud Materials Used in Gypsum- Surfactant Mud.
Depth: 12,000 to 14,791 ft, 35 days,
Total Cost: $44,000

	Tons
Barite	450
Caustic soda	1
FCL	19
CMC	1
Gypsum	1
Fine mica and nut hulls	8
DMS	11
Diesel oil	355 bbl

Lignite-Sodium Surfactant Mud

In anticipation of bottom-hole temperatures in excess of 400 F and the accompanying difficulties in control of filtration of the gypsum mud, the mud was treated with soda ash to remove the calcium ion; bicarbonate of soda to decrease the pH (had been raised by contamination by cement), and lignite to control the filtration rate. This conversion was made in one circulation of the mud. Cost was $1.40 per bbl. Filtration at 375 F and 500 psi was reduced from 60 cc to 8 cc while the API filtrate was reduced from 7 cc to 0.1 cc.

At 15,000 ft a shale formation was penetrated that caused some difficulty in the control of flow properties and, at 15,920 ft, 2 lb per bbl salt was added. The concentration of chloride ion in the filtrate was raised to 12,000 ppm. Chemical treatment for maintenance consisted in the addition of lignite to control filtration rate at 500 psi, 400



Drilling fluid history from 6000 ft to total depth of 20,603 ft, showing relation of measured characteristics through life of the hole. FIG. 5.

F at approximately 10 cc in 30 minutes, FCL as a deflocculent, DMS to provide an excess of 1 lb per bbl, caustic soda for pH control, and soda ash for the removal of calcium ion.

Field laboratory tests indicated that an addition of 0.2 lb per bbl of sodium chromate would provide improved flow properties. The addition was made while drilling at 18,600 ft and resulted in the reduction of the gels and yield point. Small additions of sodium chromate were continued thereafter.

After the well reached a depth of 19,184 ft, a 4½-in. flush-joint liner was set at 18,563 ft to allow drillstem tests on the open hole. Drillstem tests indicated that a 13.0 lb per gal mud would be adequate for existing formation pressures. Drilling below 19,184 ft continued with a 3¾-in. diamond bit. Mud weights were gradually reduced to 12.7 lb per gal. When a depth of 20,603 ft was reached, drilling was discontinued. Electrical surveys were run to total depth in the 3¾-in. hole with no difficulty. A bottom-hole temperature of 456 F was recorded.

Mud materials used in the preparation and maintenance of the lignite-sodium surfactant mud are listed in Table 5. Average daily treatments in the interval from 14,791 ft to 20,603 ft were: 0.1 lb per bbl caustic soda, 0.3 lb per bbl lignite, 0.2 lb per bbl DMS, and 0.75 lb per bbl FCL and 0.05 lb per bbl salt.

TABLE 5. Materials Used in the Lignite-Sodium Surfactant Mud.
Depth: 14,791 to 20,603 ft, 78 days,
Total Cost: $60,900

	Tons
Barite	335
Caustic soda	13
FCL	33
Lignite	48
CMC	4
Salt	9
Soda ash	4
Sodium bicarbonate	5
Sodium chromate	0.5
Fine mica and nut hulls	9
DMS	13
Diesel oil	576 bbl

The regular program of testing at the well included aging samples of mud for various periods of time at temperatures of 400 to 450 F. Treatment for filtration control was based on the results of measurement of filtration rate at 400 F and 500 psi. These tests repeatedly demonstrated the stability of the mud at bottom-hole temperatures.

Observations on Mud Performance

1. No rig time was wasted in changing from one type of mud to another.

2. No rig time was required for "conditioning mud" prior to drillstem tests, logging or other operations.

3. It was not necessary to break circulation at intermediate depths while going into the hole after the mud had remained undisturbed for as long as 36 hours.

4. Lignite was an effective, economical material for filtration control at temperatures as high as 450 F.

5. In logging and testing operations, no failures occurred that were attributed to behavior of the mud.

6. At elevated temperatures the plastic viscosity, yield point and gel strengths of the surfactant-treated mud were lower than at surface temperature.

7. Resistivity of the lignite-surfactant mud containing salt was satisfactory for logging purposes.

8. Without discarding the existing mud, alterations were made in the chemical treatment to bring about changes in properties as required to satisfy conditions of depth and temperature.

A Note on Hydraulics

High among those factors contributing to the success of drilling this deep ultra-slim hole . . . in addition to good equipment, experienced personnel, and a well-engineered mud program, was the hydraulics of the system during drilling the 1419 ft of slim-hole at the bottom. While drilling with the 3¾-in. bits to final depth, three different annulus conditions were involved, plus three different-sized drill strings and the bit itself. Without becoming involved in the mathematics and mechanics of hydraulics at this depth, some factual data on operating conditions provide an insight to results.

Bit No. 94 . . . the last bit out of this well . . . drilled from 19,932 to 20,603 ft. Weight on the bit varied from 3000 to 4000 lb while rotary speeds varied from 60 to 65 rpm. Mud weight was 13.0 lb per gal and mud viscosity was 50 sec. The drill stem while drilling with the last bit consisted of: 8962 ft of 4½-in., 5280 ft of 3½-in. and 6060 ft of 2⅜-in. drill pipe; 300 ft of 3⅛-in. drill collars with an ID of 1⅜-in.; and a 3¾-in. diamond bit on bottom. Only one of the two pumps was used for mud circulation. It was the 7¾-in. by 18-in. power-driven pump (with separate engine drive) equipped with 4½-in. liners. Pump speed was 27 strokes per minute and the pump delivered 106 gal of mud per minute at 2400 psi discharge pressure.

Those concerned with the hydraulics felt that the long strings of 4½-in. and 3½-in. drill pipe plus excellent mud characteristics were a big factor in lowering friction losses in the drill string and made it possible to deliver the required gallons per minute of drilling fluid through the bit.

Another Drilling Milestone

What does this particular well mean to the industry in terms of future deep drilling? While high bottom-hole temperature is certainly a hazard and for some time has been a barrier to deep drilling, progress and new developments in mud and downhole equipment have, for the most part, overcome problems imposed by high heat. Perhaps one of the most significant deductions to be made is in the light of future deep drilling.

Ultra-deep exploration makes up a big potential of the new wildcat horizon in the U. S. today. The number of wells going below 15,000 ft is steadily increasing year by year in the face of a decline in the total number of wells drilled. (See "Deep Drilling Finds Deep Production," *The Petroleum Engineer*, March 1960, pg. B-19.) It is interesting to note that these wells on the average are costing less than comparable deep wells of 1958. The lessons learned (or taught) by the J. O. Walker No. 1 clearly point to the application of slim-hole drilling as an exploratory device in the last 2000 ft of a deep wildcat well. And, this is the section of hole where the cost per foot generally is highest. However, even extreme heat as we know it in normal drilling operations, did not hinder drilling progress even in the very small 3¾-in. hole at bottom. And, in this section, drilling costs per foot were relatively low. The cost savings, while not detailed for comparisons here, do indicate that deep wildcatting can be programmed with slim-hole techniques on bottom, with resultant savings possible and with practical proven methods.

Acknowledgment

To the management of Penrod Drilling Company and Hunt Oil Company, both of Dallas, go thanks for permission to publish this report. Much of the data presented were provided by personnel of both companies. Acknowledgment also goes to the engineering department of Hycalog, Inc., of Shreveport, Louisiana, for diamond bit data; and especially to Dr. George R. Gray and K. D. Tanner of Baroid Division who prepared the discussion on the mud program, presented here as they wrote it.

References

1. Keen, R. E. "Drilling the World's Hottest Well," *The Petroleum Engineer*, Oct. 1957, pg. B-21.

2. Keen, R. E. "World's Deepest Slim Hole," *The Petroleum Engineer*, Mar. 1959, pg. B-30.

3. Cowan, J. C. "New Mud Features Low Filtrate Loss, Good Rheology Retention," *The Oil and Gas Journal*, Nov. 2, 1959, pg. 83. ★

R. V. Higgins, *Petroleum Research Engineer*
Bureau of Mines, San Francisco, California

You can use these . . .

QUICK METHODS OF OIL-RESERVOIR ANALYSIS

Buckley-Leverett techniques provide rapid methods for determining saturation at breakthrough, approximating relative permeability, and evaluating preferential wettability

AS PART OF A STUDY of application of the Buckley-Leverett method to an analysis of oil-reservoir performance covering a wide range of relative permeabilities and oil saturations, a method has been devised for quickly determining average water saturation at breakthrough from relative permeability data. The base for the relative permeability is the effective permeability to oil at the irreducible water saturation.

Basic data were calculated by an electronic computer and are presented in a single graph, Fig. 1, from which the point of breakthrough may be obtained. In this study the water saturation at the beginning of the depletion is the connate or interstitial or irreducible water saturation. These water saturations are considered to be synonymous and to have a practical value.

Further study of the methods devised to obtain the data in the graph showed that, by partly reversing the procedure for determining the water saturation at breakthrough, a

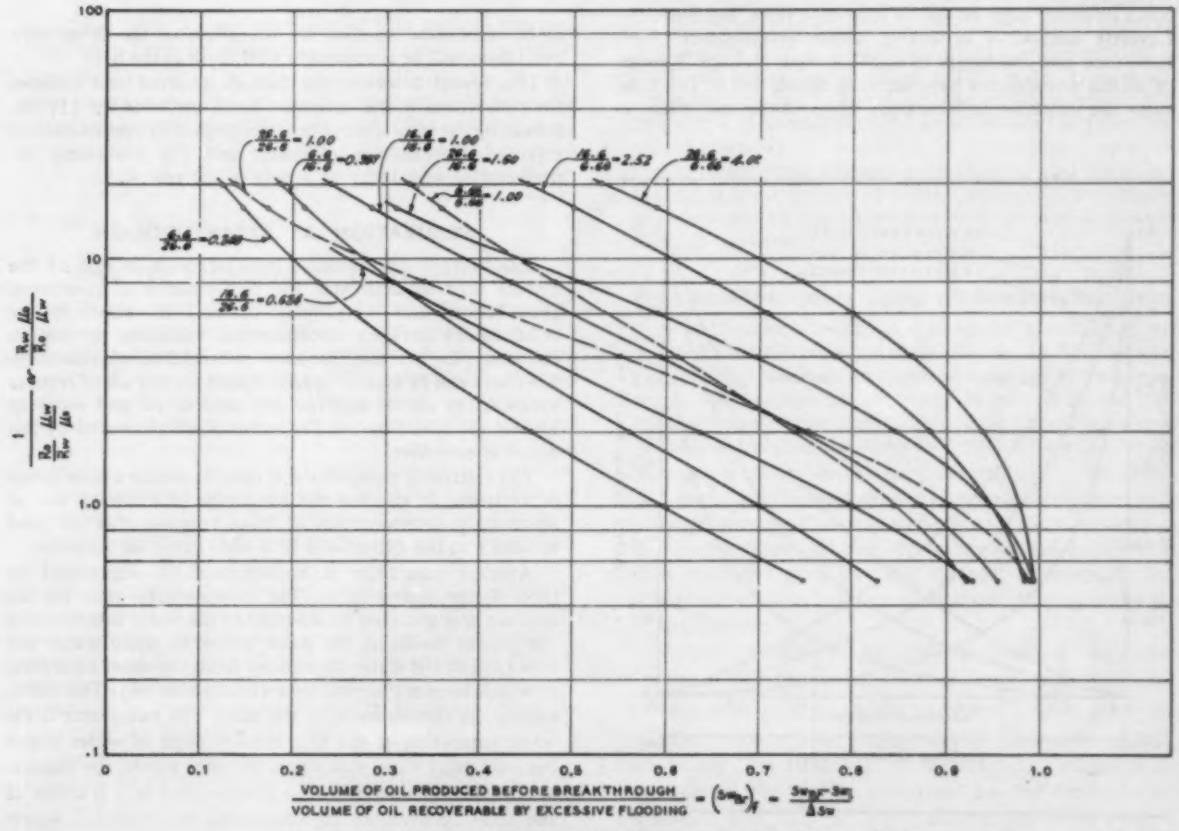


FIG. 1. Relationship between fractional water saturation (fractional oil recovery) at breakthrough and a dimensionless ratio with midpoint values of relative permeability curves as parameters.

quick method of approximating relative permeabilities on unextracted or extracted and resaturated cores can be obtained, using the same graph and very little laboratory core data. One of the purposes of the proposed method is to obtain relative permeability curves rapidly by depletion technique.

In reservoir calculations involving time or stratification, relative permeabilities are more useful than the ratio of permeabilities. When the manuscript was being prepared, no method had been published for determining relative permeabilities by depletion technique. Welge's[12] published method described the determination of permeability ratios. Recently Johnson, Bossler, and Naumann[4] presented a method to determine the relative permeabilities — not the ratios. The method for determining relative permeabilities described in this paper is a simpler technique and requires considerably fewer calculations.

Analysis of the computer data also showed that it is possible to obtain an approximate engineering valuation of preferential wettability of a core to oil or water.

Ever since Buckley and Leverett[2] published their mathematical treatment to predict the recovery performance of an oil reservoir where water or gas is the displacing medium, many technical reports have been published in which the Buckley-Leverett method enters into part of the reported work. Two recent articles, one by Cardwell[3] and the other by Blair, Douglas, and Wagner[1] present results that further support the accuracy of the Buckley-Leverett method.

The article by Blair, Douglas, and Wagner showed that, when a dimensionless rate, which includes rate, length, viscosity, and capillarity, exceeds about 16, the Buckley-Leverett method is applicable without modifications. According to this criterion, when the rates are high in small cores or either high or low in long reservoirs, the Buckley-Leverett method is applicable. Other investigators[6,8,10,11] have used rate and length to correlate their findings. Results of all the investigators have the same trend; that is, fast flow rates are required in laboratory cores if the end effect is to be minimized so that the net effect of the laboratory conditions will be comparable with those in the field.

This report describes the factors involved and outlines the procedures in the proposed quick methods for (1) determining the saturation at breakthrough, (2) approximating relative permeabilities of cores, and (3) evaluating the preferential wettability of a core to oil and water.

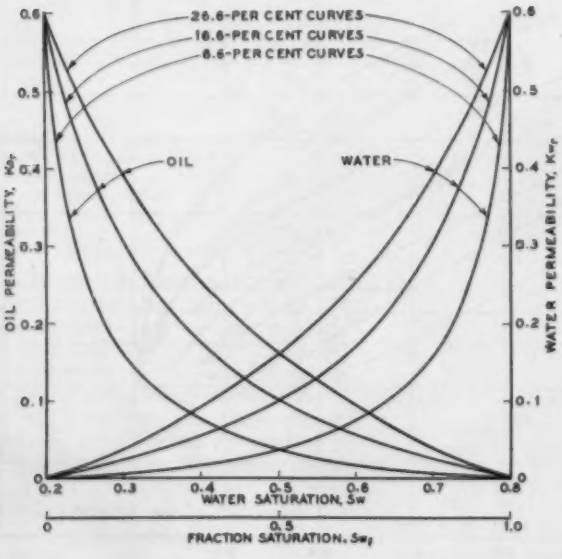


FIG. 2. Basic relative permeability curves to determine saturations at breakthrough. At midpoint where $Sw_f = 0.5$, values of relative permeabilities are 26.6, 16.6, and 6.6 percent.

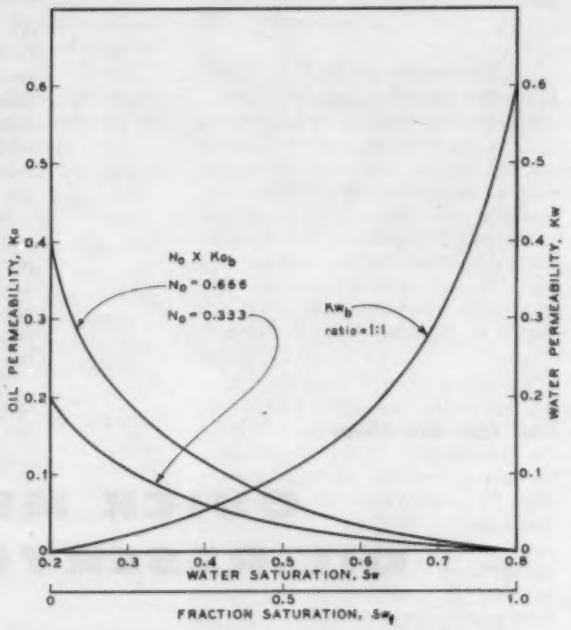


FIG. 3. Effect of multipliers on a basic curve.

SATURATION AT BREAKTHROUGH

The average saturation at breakthrough is one of the factors used to determine the performance of reservoirs. (See Pirson[9] and Welge[12] for details.) By means of the relationships between dimensionless variables, devised in this study, the average saturation at breakthrough (Buckley-Leverett) can be readily approximated for any set of relative permeability curves and for any ratio of oil and water or oil and gas (see Fig. 1). The range of data covered by this figure is extensive.

The electronic computer was used to obtain a wide range of variables. It also has the advantage of accuracy and of eliminating determination of those tangents that are hard to obtain at the extremities of a wide range of variables.

Average saturation at breakthrough is determined by three dimensionless ratios. The dimensionless ratio for the abscissa was obtained by subtracting the water saturation of the porous media at the point where no more water will flow (interstitial water saturation) from the water saturation at which no more oil will flow (irreducible oil). The difference is the denominator of the ratio. The numerator is the water saturation at the first breakthrough of water minus the interstitial water saturation. In other words, the abscissa at the point of breakthrough is expressed as a fraction of the total recoverable oil obtainable by excessive waterflooding.

The dimensionless ratio for the ordinate is

$\frac{1}{(\overline{K}_o/\overline{K}_w)\ (u_w/u_o)}$. This ratio is obtained as follows: The effective or relative permeability to oil at the saturation at which the effective or relative permeability to water is zero (symbol $\overline{K}_o$) is divided by the value of the effective or relative permeability to water at the saturation at which the effective or relative permeability to oil is zero (symbol $\overline{K}_w$). This quotient $\overline{K}_o/\overline{K}_w$ may be used as a measure of the degree of preferential wetting of the phases. The quotient is multiplied by the ratio of the viscosity of the water used to flood the media to the viscosity of the oil. The reciprocal of the product is the dimensionless ratio used for the ordinate of Fig. 1.

The parameters in Fig. 1 are the ratios of the values at the midpoint of the set of permeability curves used to obtain the point of breakthrough. For example, 26/16 means that the value at the midpoint of the relative-permeability-to-oil curve used to determine the saturation at breakthrough is 26 percent of $\overline{K}_{o_r}$, and the 16 in the 26/16 ratio means that the relative permeability to water at the midpoint is 16 percent of $\overline{K}_{w_r}$.

The following example illustrates how water saturation at the point of the first breakthrough of water may be determined, using Fig. 1. Viscosities of the oil and water used in the example are 2 and 1 centipoises, respectively. Permeability relations are shown in Fig. 4.

From the figure $\overline{K}_{o_r} = 0.70$ and $\overline{K}_{w_r} = 0.55$, the dimensionless ratio $\frac{1}{(\overline{K}_o/\overline{K}_w)\ (u_w/u_o)} = \frac{1}{(0.70/0.55)\ (1/2)}$ $= 1.57$. Water saturation at the midpoint is $\frac{(0.81 - 0.21)}{2}$ $+ 0.21 = 0.51$. At this midpoint of 0.51 the relative permeabilities have the values $K_{o_r} = 0.182$ and $K_{w_r} = 0.088$. Then $0.182/0.70 = 26$ percent and $0.088/0.55 = 16$ percent. Hence, curve 26.6/16.6, showing the ratio of midpoints of oil and water saturation, is used. The ordinate 1.57 intersects the curve at the abscissa 0.877; then the saturation at the point of breakthrough is $0.877\ (0.81 - 0.21) + 0.21 = 0.526 + 0.21 = 0.736$, or 73.6 percent water saturation, the value sought.

RELATIVE PERMEABILITY DETERMINATION

As a result of the treatment of the Buckley-Leverett concept in developing the foregoing rapid method for determining water saturation at breakthrough, the following quick method to approximate relative permeability of small oilfield cores to water and oil is proposed. In petroleum-engineering studies an average of less thorough relative-permeability determinations on many cores often is as helpful as a very thorough determination on a few cores. Also the present state of the art or science of the effect on preferential wettability of cleaning a core before making a relative permeability determination has not been clearly settled.

Accordingly, in the proposed method it is preferable that an unextracted core be used to retain the original wettability characteristics. The method depends on the influence of rapid rates of flow through the core to minimize the boundary effects on the saturation gradient. Much proof has been presented in the literature that this boundary effect is minimized by fast rates of flow.[8,11]

The proposed method involves flushing an unextracted core with an oil having the same interfacial tension between oil and water as that of the native crude. After all gas and easily removable water are flushed from the core, the effective permeability to oil is determined. This is the maximum permeability of the core to oil with a retained water content

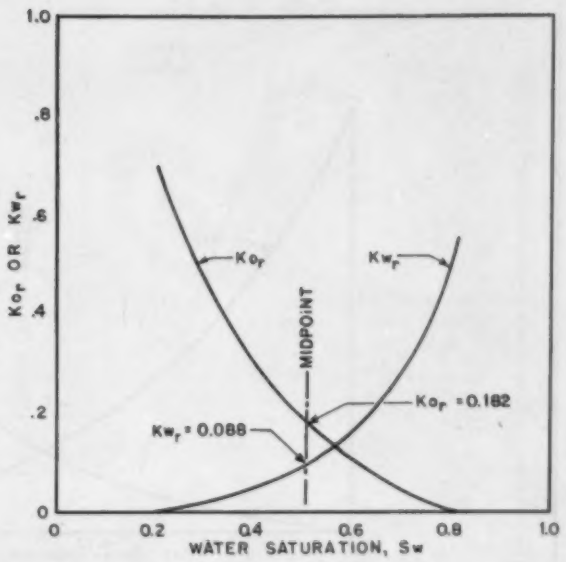


FIG. 4. Relative permeability curves used in example for approximating saturation at breakthrough.

approximating the irreducible water saturation. The irreducible water saturation is achieved by flooding with an oil the viscosity of which is similar to that in the reservoir.

Then the core is waterflooded and the quantity of oil produced before breakthrough of the water is measured. Waterflooding is continued, and the effective permeability to water is measured after the water-oil ratio is higher than would normally be economic in a flooding project. By means of these two effective permeabilities and the oil saturation at breakthrough of water, three points are obtained to determine the approximate relative permeability curves through the entire range.

Proposed Procedure Using an Unextracted Core

After the core is mounted in an epoxy[7] plastic, flush with oil until virtually no more water effluxes. In flushing use a gas-desaturated oil and pressures high enough to remove any air or hydrocarbon gas that may be present in the core. Measure the effective permeability to oil when the water-to-oil ratio is less than the order of 1/500. This effective permeability to oil has been assigned the symbol $\overline{K}_{o_e}$. Waterflood and measure the volume of oil that effluxed at the first breakthrough of water. Continue to flood until the water-oil ratio is excessive (water-oil ratio more than the order of 500/1), then measure the oil that has effluxed. If necessary, centrifuge the efflux to free any oil or water clinging to the side of the receiver.

Measure the effective permeability to water. The symbol for this is $\overline{K}_{w_e}$. Divide the effective permeability to oil, $\overline{K}_{o_e}$, by the effective permeability to water, $\overline{K}_{w_e}$. Multiply this quotient by the ratio of the viscosity of water to the viscosity of the oil. The reciprocal of the resulting product is the ordinate of Fig. 1. The reciprocal has the following significance: If $\overline{K}_o/\overline{K}_w = 1$ and if the viscosity of the water u_w is 1 centipoise, the reciprocal corresponds to the viscosity of an oil u_o. Divide the oil recovered just before the break-

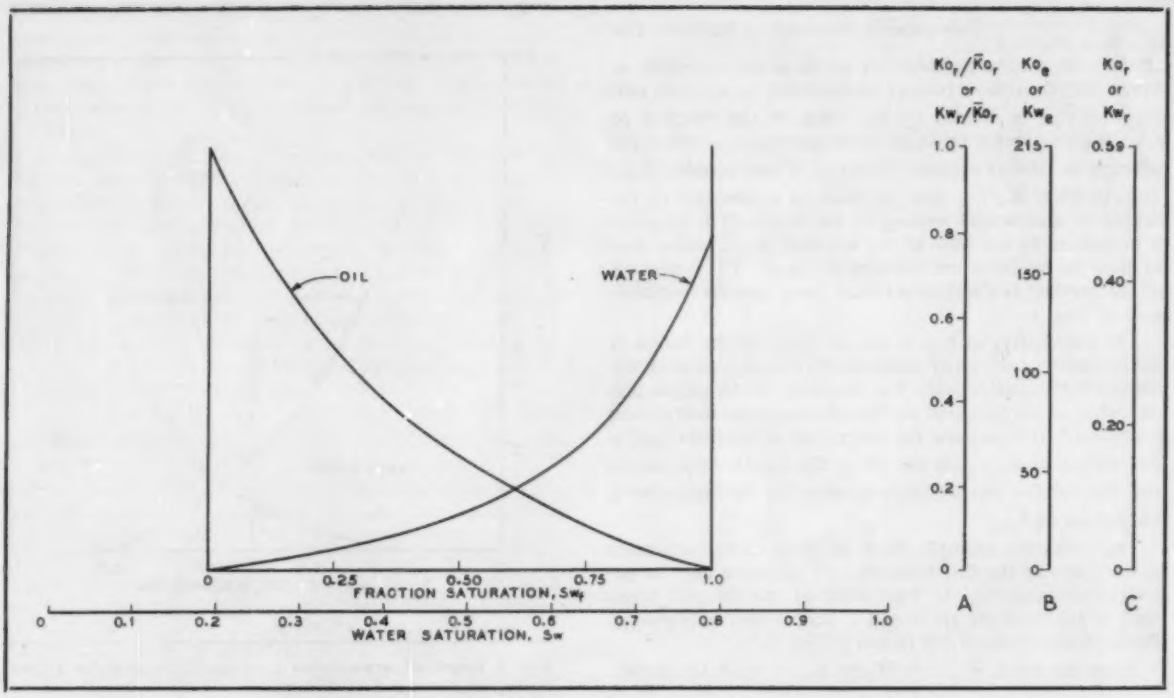


FIG. 5. Example of permeability relationship determined by proposed method.

through by the total oil recovered by flooding. This quotient is the abscissa of Fig. 1. With these data the permeability can be determined.

A hypothetical example follows: The dimensions of a core are 2.54 by 2.54 by 2.54 cm. The effective permeability ($\overline{K}_{o_w}$) to oil when the oil-to-water ratio was excessive was found to be 215 millidarcys (md). The volume of oil produced just before the first breakthrough of water was 2.24 ml; and, after virtually no more oil flowed from the core, the total effluxed oil measured 2.46 ml. The abscissa for Fig. 1 is 2.24/2.46 or 0.91. The effective permeability ($\overline{K}_{w_o}$) to water when virtually no more oil was produced was found to be 172 md.

The viscosities of oil and water used as flooding mediums were 1.60 and 0.95 centipoise, respectively. Therefore $u_w/u_o = 0.95/1.60 = 0.594$. The ratio of effective permeability to oil when virtually no more water was produced, $\overline{K}_{o_o}$, to the effective permeability of water when virtually no more oil was produced, $\overline{K}_{w_o}$, is 215/172 or 1.25. The ordinate of Fig. 1 is:

$$\frac{1}{\frac{\overline{K}_{o_o} \cdot u_w}{\overline{K}_{w_o} \cdot u_o}} = \frac{1}{\frac{215}{172} \times \frac{0.95}{1.60}} = 1.35.$$

The ordinate 1.35 and the abscissa 0.91 intersect approximately on curve 26/16. This means that a permeability relationship satisfying the curve 26/16 and adjusted for the difference in wettability, as measured by $\overline{K}_o$ and $\overline{K}_w$, will result in the same saturation at the initial water breakthrough. The value of the ordinate for $K_{o_e}/\overline{K}_{o_o}$ in Fig. 5 at the midpoint (abscissa 0.5) is 0.266 times $\overline{K}_{o_o}/\overline{K}_{o_o}$, which is 0.266 × 1.0 for this example. The ordinate for $K_{w_e}/\overline{K}_{o_o}$ at the midpoint is 0.166 times $\overline{K}_{w_o}/\overline{K}_{o_o}$ which is 0.166 × 172/215 or 0.133. With these data the complete curves as shown in Fig. 5 can be drawn.

If the abscissa and the ordinate (Fig. 1) intersect on a parameter line (no interpolation), the equation corresponding to the parameter line shown in Table 1 can be used to calculate more points for the permeability curves.

For example, additional points for curve $K_{o_e}/\overline{K}_{o_o}$ could have been obtained by using Equation 3a in Table 1. Additional points for $K_{w_e}/\overline{K}_{o_o}$ could have been obtained by multiplying the constant 0.200 in Equation 2b by 172 md/215 md and solving for the $K_{w_e}/\overline{K}_{o_o}$.

TABLE 1. — Equations to Calculate Relative or Effective Permeabilities or Ratios.

$\left(\frac{K_{o_{ef}}}{\overline{K}_o}\right) 6.66 = \frac{0.0714\,(1 - Sw_f)}{1 - 0.9286(1 - Sw_f)}$	1a
$\left(\frac{K_{w_{ef}}}{\overline{K}_o}\right) 6.66 = \frac{0.0714(Sw_f)}{1 - 0.9286(Sw_f)}$	1b
$\left(\frac{K_{o_{ef}}}{\overline{K}_o}\right) 16.6 = \frac{0.200(1 - Sw_f)}{1 - 0.800(1 - Sw_f)}$	2a
$\left(\frac{K_{w_{ef}}}{\overline{K}_o}\right) 16.6 = \frac{0.200\,Sw_f}{1 - 0.800\,Sw_f}$	2b
$\left(\frac{K_{o_{ef}}}{\overline{K}_o}\right) 26.6 = \frac{0.364\,(1 - Sw_f)}{1 - 0.636\,(1 - Sw_f)}$	3a
$\left(\frac{K_{w_{ef}}}{\overline{K}_o}\right) 26.6 = \frac{0.364\,Sw_f}{1 - 0.636\,Sw_f}$	3b

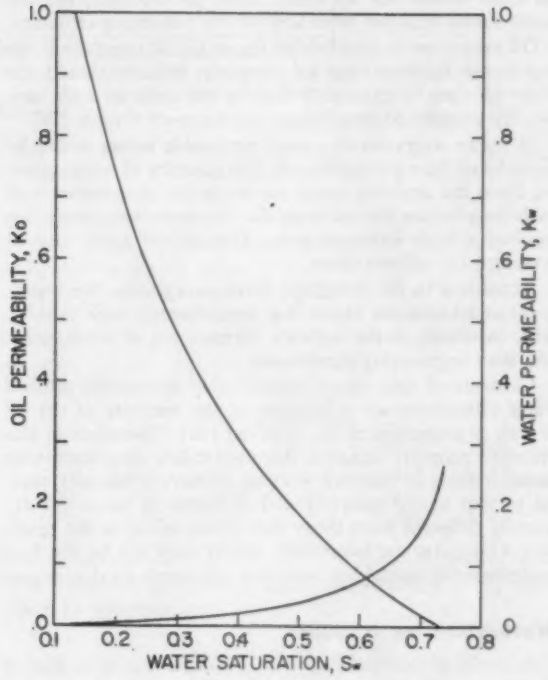


FIG. 6. Permeabilities obtained by thorough method described in report. Use of these permeabilities results in same breakthrough saturation and water-oil ratio as obtained in the laboratory.

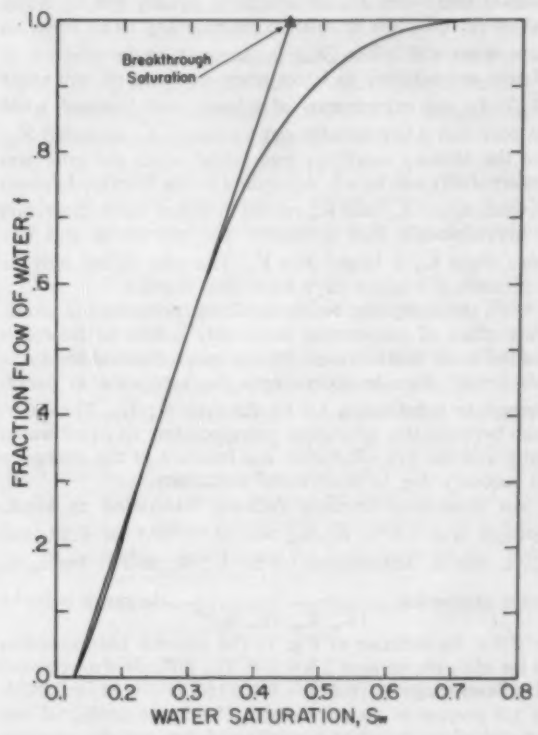


FIG. 7. Fractional flow and water saturation for the permeabilities shown in Fig. 6.

The permeability relationship obtained by the foregoing techniques is useable for engineering or computer calculations. Thus, total oil obtained by waterflooding is an index of maximum oil that can be obtained and is the extreme upper limit of reserves obtainable by waterflooding. After a recovery factor is assigned, recovery per acre-foot can be obtained readily. The basic relationship between permeability of the two phases that has been determined may be used to obtain additional reservoir information that can be calculated by mathematical and physical relationships.

If so desired, water and oil in a core sample, after being waterflooded, can be determined by extraction. Air permeability and porosity then may be determined on the clean, dry core. This latter porosity should agree within experimental limits if the oil, as well as the water, is determined by the extraction method and used to calculate porosity. With the additional information, percentage saturation of water at which the flow of oil virtually ceases to remove any water can be calculated. This percentage may approach the irreducible water saturation determined by capillary methods because a high rate of oil flow is used.

Continuing with the foregoing hypothetical example and the additional hypothetical experimental data, water content of the core was found to be 3.24 ml and the oil 0.86 ml. Porosity measured by the liquids is $\frac{3.24 + 0.86}{2.54 \times 2.54 \times 2.54} =$ 25 percent. Porosity, measured by expansion of gas, was found to be 25.5 percent. Approximate irreducible water saturation by flushing with oil is $\frac{3.24 - 2.46}{3.24 + 0.86} = 19$ percent, where 2.46 is the number of ml of floodable oil from the previous example. Percentage of floodable oil is $\frac{2.46}{3.24 + 0.86}$ = 60 percent. Approximate irreducible oil saturation is $\frac{0.86}{3.24 + 0.86} = 21$ percent.

These three percentages are shown by the abscissa on the top scale in Fig. 3. This abscissa differs by a multiple and an added constant from that of the lower scale.

The air permeability was found to be 365 md. Then, relative permeability to oil $\frac{215}{365} = 0.59$, and relative permeability to water is $\frac{172}{365} = 0.47$. These can be read from the C scale in Fig. 5. The C-scale factor differs by a multiple from the factor for the A scale. The C scale and upper abscissa are the usual ways the data are presented, but the additional information contained therein is not required for most engineering calculations of reservoir performance.

WETTABILITY

The literature contains much information about preferential wettability of reservoir rocks by either water or oil and each paper contributes to the subject. Although various methods of measuring its effects have been described, so far the relationships of wettability measurements on recovery of oil have been more qualitative than quantitative with respect to their direct application to reservoir analysis. Until investigators obtain the final answer, the method described below can be helpful to reservoir engineers.

The method is based on the relationships in Fig. 1 and assumes that when a core sample is equally wet by water and oil the effective or relative permeability to oil when no more water will efflux ($\overline{K}_o$) is the same as the effective or relative permeability to water when no more oil will efflux ($\overline{K}_w$). In the experiments of Kinney and Nielsen[5] when the core was preferentially wet by water, $\overline{K}_o$ exceeded $\overline{K}_w$, and the reverse condition was found when the core was preferentially wet by oil. According to the Buckley-Leverett method, larger $\overline{K}_o$ than $\overline{K}_w$ results in higher water saturation at breakthrough, that is, higher recovery of oil and vice versa when $\overline{K}_w$ is larger than $\overline{K}_o$. This also agrees with the experimental findings of Kinney and Nielsen.

With the foregoing background, the procedure in evaluating effect of preferential wettability is first to determine saturation at breakthrough by the quick method shown in this report, then to redetermine the saturation at breakthrough by substituting 1.0 for the ratio $\overline{K}_o/\overline{K}_w$. The difference between this saturation corresponding to equal wettability and the first saturation is a measure of the change in oil recovery due to preferential wettability.

An illustrative example follows: Saturation at breakthrough was 0.877, $\overline{K}_o/\overline{K}_w$ was 0.70/0.55 or 1.27, and u_w/u_o was ½. Substituting 1.0 for $\overline{K}_o/\overline{K}_w$ and ½ for u_w/u_o in the expression $\frac{1}{(\overline{K}_o/\overline{K}_w)(u_w/u_o)}$, the result is $1 \div ½$ or 2 for the ordinate of Fig. 1. The abscissa corresponding to the ordinate value of 2 is 0.846. The difference in recovery at breakthrough is $(0.877 - 0.846)(0.81 - 0.21) = 0.0186$, or 1.9 percent of the pore space. This is the additional volume of oil produced at breakthrough because the reservoir was preferentially water wet. The 0.81 and 0.21 used in the foregoing equation are water saturations at $\overline{K}_o$ and $\overline{K}_w$, respectively.

Because of the absence of experimental data, it was assumed that reverting to equal wettability does not alter the constancy of the multipliers N_o and N_w around the midpoint region. When experimental data are available, this factor, if it exists, could easily be included by using Fig. 1.

A quick wettability index, but one that does not express the effect of wettability in terms of recovery, employs the ratio $\overline{K}_o/\overline{K}_w$. In this example the ratio is 1.27 and means that the core is water wet.

Examination of literature shows that there is a noticeable trend regarding water saturation and wettability. The water saturation at $\overline{K}_o$, the interstitial water saturation (Sw_i), is higher for water-wet cores compared with oil-wet cores. Also, water saturation (Sw_m) at $\overline{K}_w$ is higher.

DISCUSSION

Wettability

When a raw core is exposed to air, oxidation can take place. Oxidation presents a more serious problem when using imbibition methods to measure wettability than when using the method proposed in this report for evaluating wettability. In the imbibition methods oxidation to "a depth of one sand grain in diameter" at the sand face may dominate the results of the imbibition tests. By the wettability method of this report all the sand grains would affect the test. Moreover, sweeping the core with oil would remove all the soluble oxidized hydrocarbons that would more easily go into solution than adhere to the sand grains by adsorption.

Water-Oil Ratios

For reservoirs in which the accumulation of oil was the result of oil migrating up structure into traps and the displacement of water down structure, the oil-water or water-oil ratio would not approach zero, as the down-moving water would be active when any oil was moving up structure.

Oil saturation at and behind the water-oil interface is the key factor in estimating oil recovery. Seldom should the water-oil ratio be extremely high in this area, as wells usually are abandoned long before the water-oil ratio is 100.

In many reservoirs the more permeable layers would be depleted of their producible oil. The quantity of water entering from the depleted sands results in the abandonment of wells long before the oil from the less permeable zones has reached a high water-oil ratio. This would apply also to preferentially oil-wet sands.

According to the foregoing three paragraphs, the water-to-oil or oil-to-water ratios that are extremely high in these three instances, in the author's opinion, are of more scientific than engineering significance.

Contents of this report indicate that irreducible oil and water saturations are a function of the viscosity of the oil as well as properties of the reservoir rock. The effect of this viscosity property suggests the desirability of determining permeabilities of the rock with an oil having viscosity similar to that in the reservoir and at water-oil ratios not extremely different from those that would occur in the reservoir. Otherwise the laboratory results may not be the best representative model for reservoir engineering calculations.

Wettability as a Guide

A study of permeability data available indicates that if $\overline{K}_o$ is higher than $\overline{K}_w$ (preferentially water wet), the permeability to oil at the mid-point will be correspondingly high. This indicates that the reservoir rock continues to conduct readily the oil phase throughout the entire saturation range and vice versa if $\overline{K}_w$ is higher than $\overline{K}_o$. If $\overline{K}_w$ and $\overline{K}_o$ are at or near equality, then the midpoints are both high, indicating that if the reservoir rock conducts equally well at the upper extremities it will continue to do so during the entire permeability range.

Using these observations as guides, if the area of interest in Fig. 1 lies where there is an alternate choice, the one satisfying the foregoing observations would be chosen. If a more accurate choice is required, then a determination of one or two permeability ratios of the phases after breakthrough can be used.

THOROUGH METHOD FOR PERMEABILITY

The general procedure for the thorough method is: (1) obtain the K_o and K_w curves from Fig. 1, based on laboratory data, using wettability as a guide to the midpoint of the K_o curve; (2) retain the values of K_o and K_w to breakthrough; and (3) "tailor fit" the K_o and K_w by slightly altering them after breakthrough to result in the same K_w/K_o ratios as are obtained from laboratory data.

For example, using laboratory data presented in the literature, average saturation at breakthrough $Sw = 0.454$, or $Sw_f = 0.538$. As the $\overline{K}_w$ is 0.264 times $\overline{K}_o$, the core is decidedly water wet; therefore a K_o curve having a high value at the midpoint was chosen. Using Fig. 1, the ratio of the midpoints by extrapolation was found to be 26.6/9.87. K_o and K_w from these relationships are shown in columns 2 and 3 of Table 2 and the altered ones (average deviation about 4 percent) after breakthrough in columns 4 and 5. Ratios after breakthrough from the laboratory data are shown in column 6 of Table 2. The plot of the data in columns 2 and 3 to breakthrough and columns 4 and 5 after breakthrough is shown in Fig. 6, and of the f function, in Fig. 7.

TABLE 2. Relative Permeabilities Obtained from Fig. 1 and Slight Adjustments After Breakthrough to Conform to Laboratory Data.

Saturation	Permeability to oil from equation* (1.2),	Permeability to water from equation (2.2),	Adjusted permeability to oil,	Adjusted permeability to water,	Ratio from laboratory data,
Sw	K_o	K_w	K_o	K_w	K_w/K_o
1	2	3	4	5	6
		Before breakthrough			
0.200	0.723	0.004	—	—	—
.250	.586	.007	—	—	—
.300	.475	.011	—	—	—
.350	.384	.016	—	—	—
.400	.307	.021	—	—	—
.450	.242	.028	—	—	—
		After breakthrough			
.500	.186	.038	0.189	0.038	0.201
.550	.137	.051	.133	.052	.391
.600	.094	.069	.089	.073	.823
.650	.056	.098	.052	.107	2.06
.700	.022	.150	.021	.153	7.27

*The equations for K_o with the 26.6 midpoint and K_w with the 9.87 midpoint are:

$$K_o = \frac{0.593\ (9.736 - Sw)}{1 - 1.046\ (0.736 - Sw)} \quad . \quad . \quad . \quad (1.2)$$

$$K_w = \frac{.0473\ (Sw - 0.126)}{1 - 1.426\ (Sw - 0.126)} \quad . \quad . \quad . \quad (2.2)$$

K_o and K_w, as shown in Fig. 6, determined by the foregoing method of this paper have these useful properties for the reservoir engineer: (1) Their use will result, by the Buckley-Leverett method or by the extension of the Welge tangent, in the same breakthrough saturation as was obtained in the laboratory; (2) their use will also result in the same water-oil ratio and saturation relationships after breakthrough as was obtained in the laboratory; and (3) the effect of wettability as indicated by the position of $\overline{K_o}$ and $\overline{K_w}$ can be measured by the saturation at breakthrough or the recovery at any water-oil ratio.

CONCLUSION

This report correlates information on wettability and permeability in a manner useable to the reservoir engineer. A rapid method for approximating and a longer but more accurate method for determining relative permeabilities are presented, which provide useful data for the reservoir engineer.

NOMENCLATURE

d, g, b, and c are constants, the value of which depends on the shape of the relative permeability curve.

$f = \dfrac{1}{1 + \dfrac{K_{o_r}\, u_w}{K_{w_r}\, u_o}}$ = fractional flow, dimensionless.

f' = derivative of f.

f_{Sw_a} = fractional flow value used in determining the saturation at breakthrough.

f_{Sw_b} = another fractional flow value used in determining the saturation at breakthrough.

$\overline{K_o}$ = effective or relative permeability to oil when the effective or relative permeability to water is zero.

$\overline{K_w}$ = effective or relative permeability to water when the effective or relative permeability to oil is zero.

K_{o_r} = relative permeability to oil, dimensionless.

K_{w_r} = relative permeability to water, dimensionless.

K_{o_e} = effective permeability to oil, md.

K_{w_e} = effective permeability to water, md.

$\overline{K_{o_r}}$ = relative permeability to oil when the relative permeability to water is near or zero, dimensionless.

$\overline{K_{w_r}}$ = relative permeability to water when the relative permeability to oil is near or zero, dimensionless.

$\overline{K_{o_e}}$ = effective permeability to oil when the effective permeability to water is near or zero, md.

$\overline{K_{w_e}}$ = effective permeability to water when the effective permeability to oil is near or zero, md.

$\overline{K_o}/\overline{K_w} = \overline{K_{o_r}}/\overline{K_{w_r}} = \overline{K_{o_e}}/\overline{K_{w_e}}$, dimensionless.

K_{o_b} = basic curve for relative permeability to oil.

K_{w_b} = basic curve for relative permeability to water.

N_o = multiplier to change the basic curve for the relative permeability to oil.

N_w = multiplier to change the basic curve for the relative permeability to water.

Sw = water saturation.

Sw_c = commencing water saturation – in this paper is Sw_i.

Sw_{Br} = water saturation at breakthrough.

Sw_f = fractional water saturation.

Sw_i = interstitial water saturation.

Sw_m = water saturation at $\overline{K_w}$ – maximum water saturation obtainable by flooding with many more pore volumes than that used in field practices.

$\Delta Sw = Sw_m - Sw_i$.

u_w/u_o = ratio of water viscosity to oil viscosity.

BIBLIOGRAPHY

1. Blair, P. M., Douglas, Jim, Jr., and Wagner, R. J., "Calculations of Linear Water Flood Behavior, Including the Effects of Capillary Pressure." *Trans.* AIME, Petrol. Development and Technol., T.P. 8013, 1959, pp. 96-102.

2. Buckley, S. E., and Leverett, M. C., "Mechanisms of Fluid Displacement in Sands." *Trans.* AIME, Petrol. Development and Technol., vol. 146, 1942, pp. 107-116.

3. Cardwell, W. T., Jr., "Solution of Immiscible Displacement Equations Without Triple Value." Preprint, Paper 928-G, AIME Meeting, Dallas, Tex., Oct. 6-9, 1957, pp. 1-10.

4. Johnson, E. F., Bossler, D. P., and Naumann, V. O., "Calculation of Relative Permeability From Displacement Experiments." AIME *Jour. Petrol. Technol.*, Tech. Note 2027, January 1959, pp. 61-63.

5. Kinney, P. T., and Nielsen, R. F., "Wettability in Oil Recovery." *World Oil*, March 1951, pp. 145-154.

6. Kyte, J. R., and Rapoport, L. A., "Linear Waterflood Behavior in Water-Wet Porous Media." Preprint, Paper 929-G, AIME Meeting, Dallas, Tex., Oct. 6-9, 1957, p. 7.

7. Loomis, A. G., and Crowell, D. C., "Relative Permeability Studies: I. Gas-Oil Systems." *Producers Monthly*, September 1958, pp. 12-24.

8. Moore, T. F., and Slobod, R. L., "Displacement of Oil by Water-Effect of Wettability, Rate, and Viscosity on Recovery." Preprint, Paper 502-G, AIME Meeting, Oct. 2-5, 1955, pp. 1-10.

9. Pirson, Sylvain J., *Elements of Oil-Reservoir Engineering*. McGraw-Hill Book Co., Inc., New York, N. Y., 2d ed. 1958, p. 561.

10. Rapoport, L. A., and Leas, W. J., "Property of Linear Water Floods." *Trans.* AIME, Petrol. Development and Technol., vol. 198, 1953, p. 139.

11. Sandberg, C. R., Gournay, L. S., and Sippel, R. S., "The Effect of Fluid-Flow Rate and Viscosity on Laboratory Determinations of Oil-Water Relative Permeability." *Jour. Petrol. Technol.*, T. P. 8003, 1958, p. 36.

12. Scarborough, James B., *Numerical Mathematical Analysis*. Johns Hopkins Press, Baltimore, Md., 1950, p. 129.

13. Welge, H. J., "A Simplified Method of Computing Oil Recovery by Gas and Water Drive." *Trans.* AIME, Petrol. Development and Technol., vol. 195, 1952, pp. 91-98.

★ ★ ★

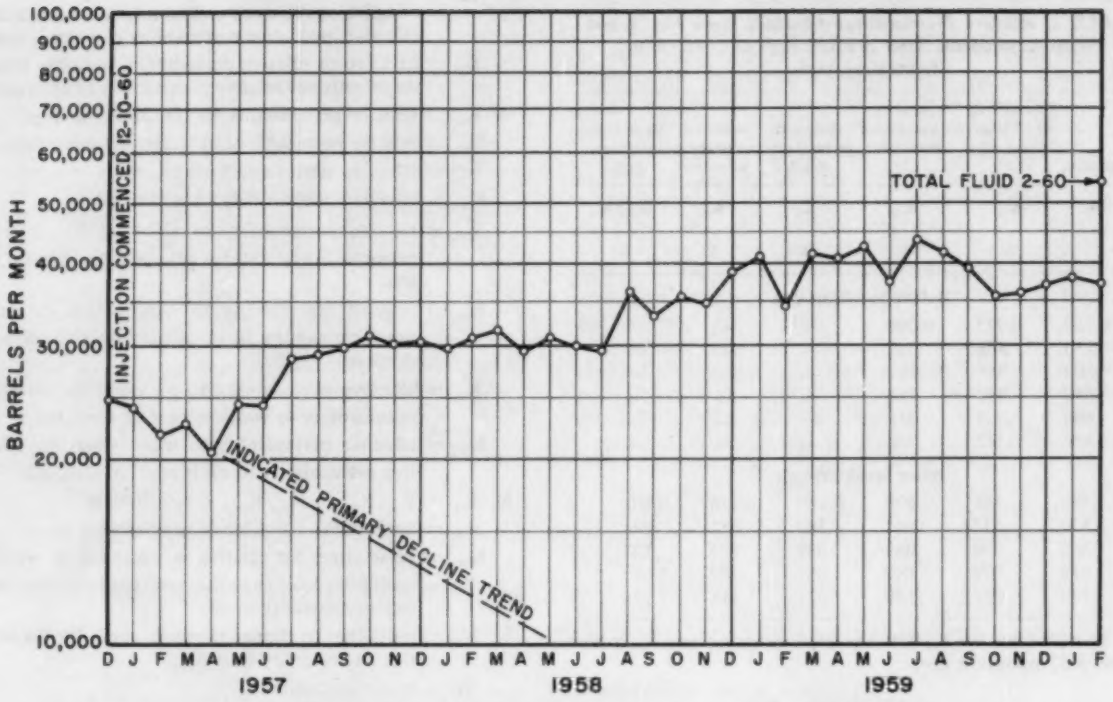


FIG. 1. Production history of the oldest waterflood in Western Nebraska, started late in 1956. Over 4 million bbl of water had been injected through 7 injection wells by February 1, 1960.

IN CRETACEOUS SANDS . . .

Secondary Recovery Booms in Western Nebraska

Waterfloods, miscible-phase programs, and dry gas injection promise 55 million bbl of secondary oil from this active area

H. N. Rhodes, *Director, Nebraska Oil and Gas Conservation Commission, Sidney, Nebraska*

SECONDARY RECOVERY and pressure maintenance projects are rapidly gaining favor in the Western Nebraska portion of the Denver-Julesburg Basin. Eleven waterflood installations, one miscible phase program and one dry gas injection project are currently operating in the area. Five water floods are under construction and 19 additional Western Nebraska fields are in various stages of investigation, project design or unitization.

Experience has indicated that thin Cretaceous sands encountered in the area will respond readily to secondary recovery methods. Newly discovered fields are developed with an eye toward future secondary operations. It is estimated that 55 million bbl of secondary oil will eventually be recovered from Western Nebraska reservoirs.

Forty-acre well spacing prevails in the majority of Western Nebraska fields. Suitable injection patterns are established by converting producing wells for fluid injection. Dry holes are often re-entered to fill out the flood pattern.

Virtually all projects, now operating or proposed for the future, involve some type of unitization agreement. Unitization is accomplished with little difficulty in most cases. Operators and royalty owners alike accept secondary recovery and unitization as being in the best interest of all concerned.

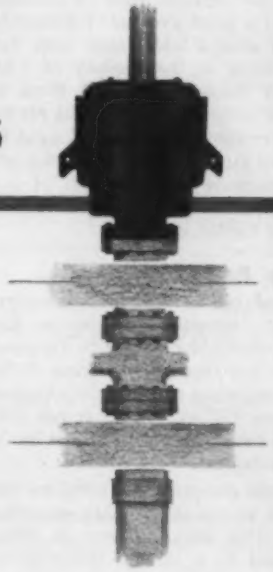
Formation Characteristics

Western Nebraska fields produce from the "D" and/or "J" sands of Cretaceous age at depths ranging from 5500 to 7000 ft. The "D" and "J" sands are shallow-water, nearshore, marine deposits similar in many respects to sediments now being deposited along the Atlantic and Gulf coasts. There are at least five distinct stratigraphic intervals in the "J" sand group and three in the "D." Each interval is separated from the other by minor shale breaks. The sands of each interval take the

in an emergency...

IT'S WHAT'S ON TOP THAT COUNTS!

HYDRIL BLOWOUT PREVENTERS



And when "what's on top" is a Hydril Blowout Preventer, you *know* you can shut off your well in a jiffy when the need arises... no matter what member of the drill string is in the preventer... no matter if there is *nothing at all in the hole!*

Then, with the well securely shut in, you can safely go about the business of correcting the trouble and regaining control.

THERE'S A HYDRIL BLOWOUT PREVENTER FOR EVERY KIND OF WELL!

THE FAMOUS "GK": for most wells, deep holes, high pressures... proved by more than 15 years' experience in every oilfield in the world!

SUPER "GK-10,000": for deepest drilling and highest pressures... here's the renowned "GK" beefed up for the toughest jobs!

"MSP-2000": for low-pressure wells... for remedial and workover jobs... this lighter weight "GK" type preventer provides an extra margin of safety.

HYDRIL TAKES THE "BLOW" OUT OF BLOWOUTS!

HYDRIL COMPANY

714 West Olympic Boulevard, Los Angeles 15, California

Factories at: Los Angeles; Houston, Texas; Rochester, Pa.

Sales Offices—California: Bakersfield, Los Angeles, Ventura **Louisiana:** Harvey, Lafayette, New Iberia, Shreveport **Oklahoma:** Oklahoma City, Tulsa. **Texas:** Corpus Christi, Dallas, Houston, Midland, Odessa. **Wyoming:** Casper **New York:** New York. **Canada:** Calgary, Edmonton

form of a series of isolated lenses. Virtually every known sand lens is productive or potentially productive from its updip edge.

Oil accumulations are confined within stratigraphic traps which may or may not exhibit a degree of anticlinal structure. Structural closure is necessary for oil accumulation only in those limited portions of Western Nebraska where the producing sands become continuous. Reservoirs are often delineated by permeability pinchouts around the entire periphery.

The porosity of Western Nebraska Cretaceous reservoirs will usually be less than 20 percent, with 18 percent serving as a good average. Permeabilities vary over a wide range with the average lying in the vicinity of 130 mds. Pay thicknesses range from a minimum of 3 ft to as much as 60 ft. A well encountering 10 ft of sand is considered a good investment, although wells possessing less than 5 ft of net sand have, on occasion, delighted operators and baffled engineers.

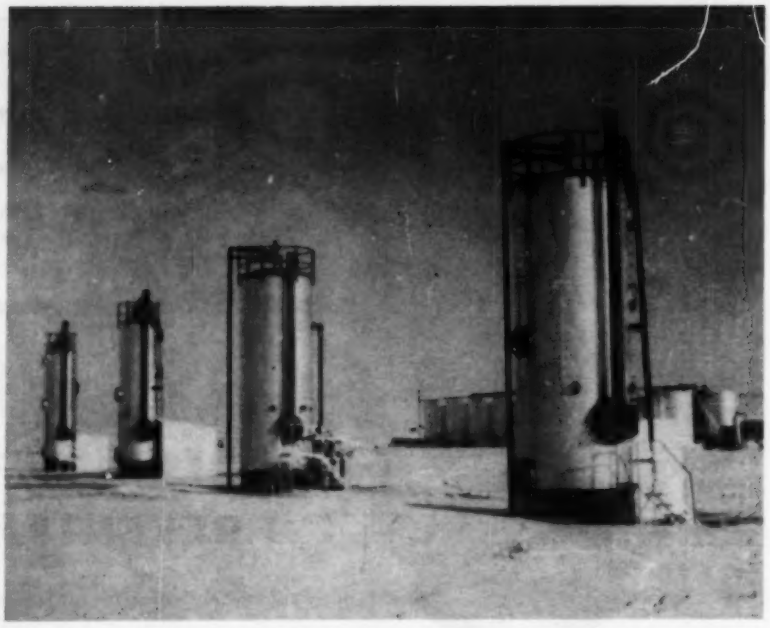


FIG. 2. Consolidated tank batteries assist in cutting operating costs. This typical installation is in the Barrett field of Western Kansas.

Primary Performance

Original oil in place in Western Nebraska reservoirs will be on the order of 900 bbl per acre-ft. Original reservoir pressures range from 1050 to 1300 psi, while solution gas-oil ratios vary from 220 to 900 cu ft per bbl. Crude is sweet with an API gravity of 37 to 40 degrees.

Solution gas normally provides the principal source of primary reservoir energy. This major source is often augmented by a limited water drive, although the existence of such a driving force is usually difficult to confirm. A small number of fields in the area enjoy the benefits of an active water drive which may not manifest itself until the middle or later stages of primary depletion.

Primary recovery from reservoirs producing under a solution gas or depletion drive mechanism is on the order of 180 bbl per acre-ft, or 20 percent of the original oil in place; however, a number of reservoirs which ostensibly produce solely under depletion drive mechanisms are now indicating primary recoveries on the order of 24 percent of the original oil in place.

Initial production rates run as high as 2000 bbl per day, with the average falling around 150 bbl per day. Primary decline trends follow a six percent per month curve. Wells respond favorably to fracture treatment and other standard workover operations.

Secondary Performance

Reservoirs respond rapidly to water injection regardless of the stage of primary depletion at the time injection is commenced. Some reservoirs have demonstrated production increases in as little as 30 days following the commencement of injection. Others may require four to six months of continuous injection before any deviation from the primary decline trend is observed.

Susceptibility testing shows that injection of 1.6 to 2.3 pore volumes of water may be necessary to achieve complete floodout. Most projects will have a life of 6 to 10 years under secondary operation depending on the flood pattern and the quantity of water injected per unit time.

Recovery wells are inclined to waterout at a rapid rate, with many wells progressing from 100 percent oil to 95 percent water in a period of 30 to 90 days. This is probably an indication of favorable sweep efficiencies and high overall flood conformance.

Fig. 1 is a plot of production against time for the oldest water flood in Western Nebraska. Water injection has been carried out continuously in this field since late in 1956. Over 4 million bbl of water had been injected to February 1, 1960. This particular project involves 23 recovery wells and 7 water injection wells. The flood pattern is best described as a modified line-drive.

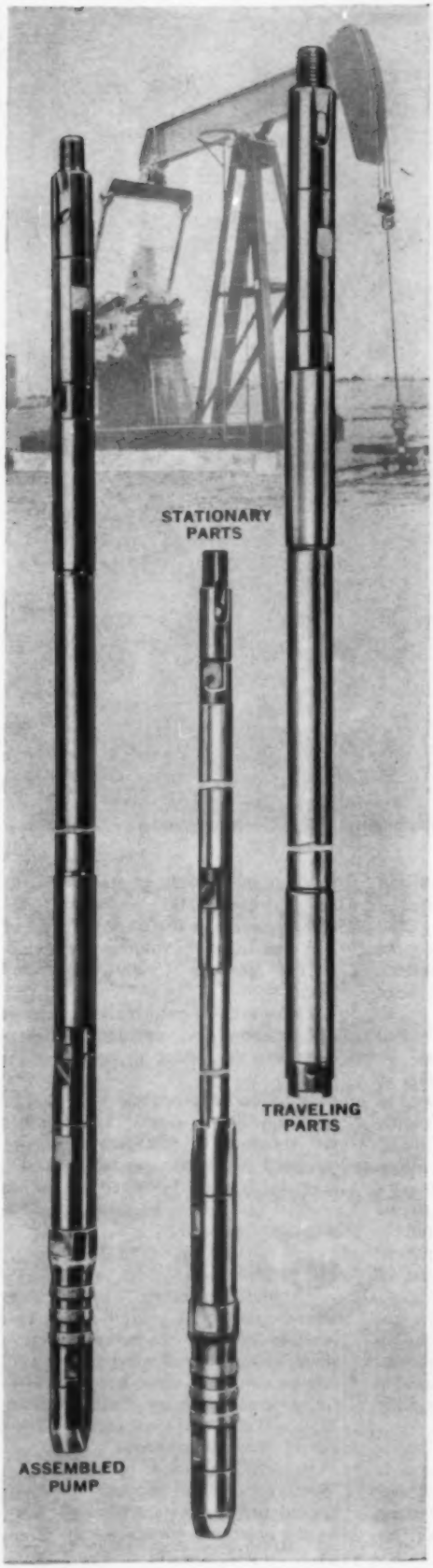
It is noted that no sharp production increase has been realized since the commencement of injection; rather, injection has arrested the normal primary decline and has afforded a gradual increase in production over the three year period. In all probability, a closely spaced pattern flood would have provided a much sharper production increase.

The majority of water injection projects in the Western Nebraska area utilize line-drive or semi-peripheral flood layouts. One "planned-pattern" flood has recently been installed and a full peripheral flood will be commenced shortly. Initial flood layouts are usually modified as the flood progresses.

Depending on the philosophy of their employers, engineers estimate that total recovery by both primary and secondary energy sources will range from 32 to 45 percent of the original oil in place. Operators with greater experience are inclined to subscribe to the higher estimates.

The single miscible phase program operating in the area is proving successful in the opinion of the operator. Production has been maintained at a level substantially above that rate anticipated by extrapolation of the previously established primary decline. The project has been in operation slightly less than two years. Minor gas breakthrough has been noted in recent months. Water injection is contemplated if gas breakthrough becomes a major problem.

Pressure maintenance through the injection of dry gas into a primary gas cap is expected to double the recovery from a large field in Western Nebraska. Gas injection was commenced at a time when primary reservoir energy was nearly depleted. Reservoir pressure was restored to its original level



Here are some money-saving tips about deep-well pumping

EVERY WELL OPERATOR wants to get his production at lowest cost, and proper selection of equipment can contribute substantially toward achieving this goal.

When pumping below 7,000 feet, for example, it is a frequent practice to install 1¼" standard barrel pumps in 2" tubing. This combination is not economical in many of the deeper wells because high pressures cause distortion of the pump barrel and excessive wear on pump parts, necessitating costly stoppages to pull the pump for maintenance work. At these depths, impact loading often causes the early failure of standard-wall pump barrels.

"Oilwell" builds HEAVY-WALL pump barrels

... with thicker walls which have the strength to operate properly under high pressure conditions. Furthermore, these pumps (1¼" maximum for 2" tubing, 1¾" for 2½" tubing) can be made to produce as much fluid by a compensating increase in stroke length, pumping speed, pumping time, or a combination of all three.

Periods between maintenance pullings may be further extended by utilizing: (1) bottom-seated pumps, which will not stretch under pressure; (2) double valves instead of single valves; and (3) "stroke through" assemblies—all of which add to efficiency in deep well pumping.

You can get heavy-wall construction in HI-BRIN or KROM-I-DEE qualities. Each of these exclusive "Oilwell" barrels is strong and abrasive-resistant and designed to meet a particular corrosive condition.

Write or ask for a free copy of *Selection and Application of Subsurface Pumps*. Its 38 pages are crammed with practical information. Or visit your "Oilwell" store and talk with our Pumping Specialists. They can help you select the subsurface pump that will perform most economically in your well.

USS, HI-BRIN, KROM-I-DEE and "Oilwell" are registered trademarks

USS Oil Well Supply Division of United States Steel

Executive Offices—Dallas, Texas
Export Office—30 Rockefeller Plaza, New York 20, N. Y.

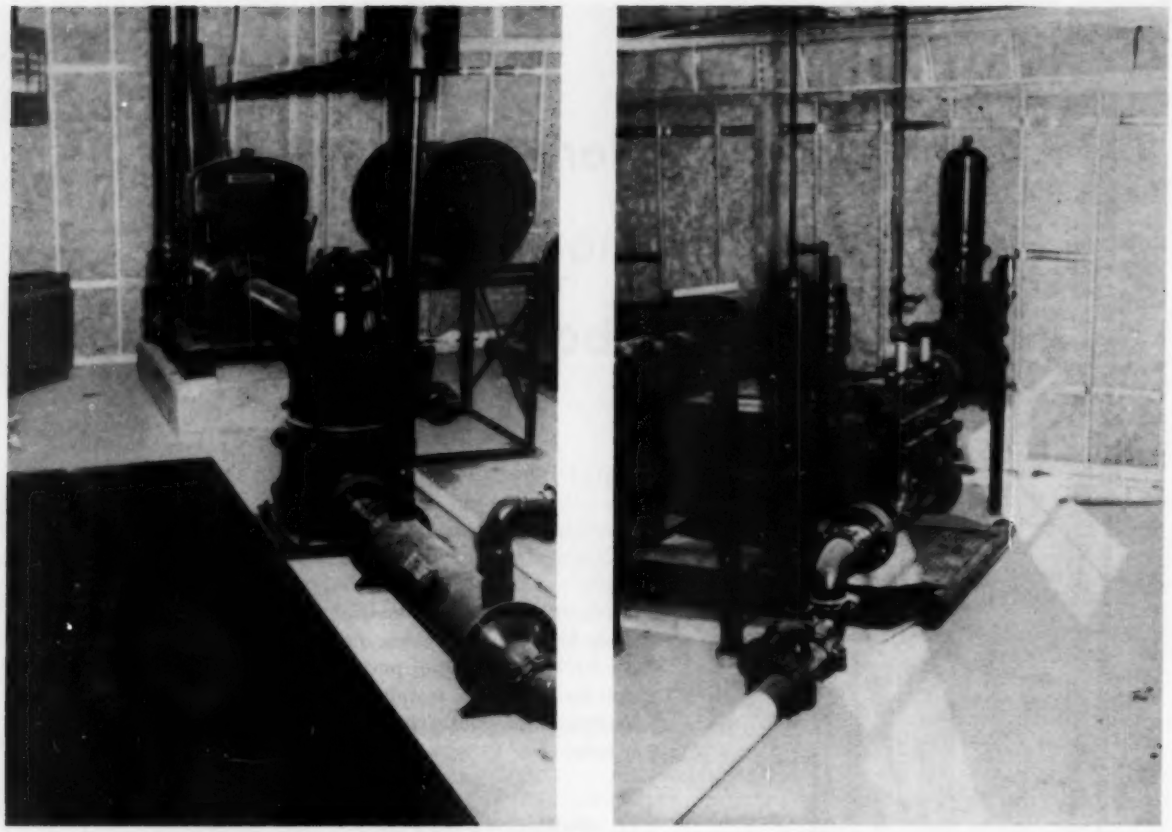


FIG. 3. Typical plant design is simple, functional, and uncluttered. The water supply well (left) is situated in the same building with the pumps, filters, etc. (right).

and production was correlated with injection to allow reservoir pressure to decline at a predetermined rate. Extrapolation of primary decline curves indicated recovery of only 15 percent of the original oil in place under the primary producing mechanism. Performance now indicates that re-pressuring and controlled withdrawals will add at least 15 percent of the original oil in place to the total recovery.

Water Supply

Water for secondary recovery is usually obtained from shallow Tertiary gravels or highly fractured clays. Most water source wells are less than 200 ft in depth with an occasional well bottomed below 300 ft. Source wells are often capable of producing 1200 gal of water per min. Wells are usually produced with vertical turbine pumps. Shallow ground water is plentiful in most areas of Western Nebraska and no lowering of local water tables has been noted to date.

High quality injection water is universally obtained. Analysis indicates total solids on the order of 350 ppm, with no plugging tendencies noted. Sand and clay particles may cause temporary filtration problems following completion of a new supply well, but water quality improves in a matter of a few weeks. Sulfate-reducing and slime-forming bacteria have been detected but have caused no problems. Bactericidal treatment has not been necessary.

Plant Design

The design of injection plants in Western Nebraska can be described as simple and functional. Water supply wells discharge directly to the pump suction through cartridge-type filters. Internal combustion engines are employed almost exclusively due to the remoteness of many projects and the relatively high cost of electric power. Radiators are discarded in favor of heat exchangers for engine cooling.

Positive displacement pumps are generally installed in each plant, although water injection may be accomplished with the vertical turbines at the water supply wells during the early stages of the project.

In most installations now being constructed, mechanical filtration is accomplished through the use of cartridge-type filters. Cartridge life is on the order of 3000 bbl of water per cartridge, with longer life to be anticipated as the project progresses. Plants are constructed for maximum injection pressures in the neighborhood of 1200 psi. Injection volumes are usually in the 5000 to 15,000 bbl-per-day range.

Plants are designed for long periods of unattended operation. Downtime has been less than three percent in most plants.

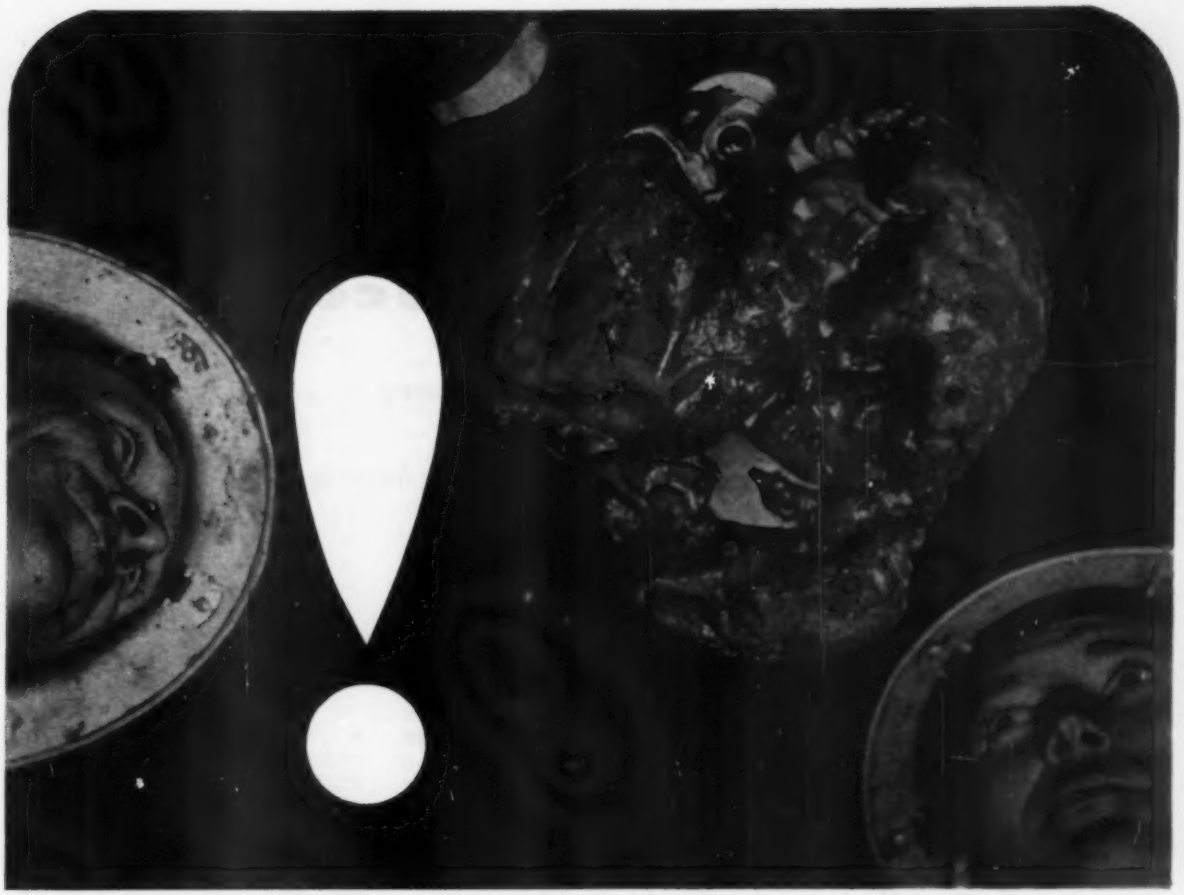
Injection of produced water is not common at this time. Corrosion has not presented a problem, and unwrapped pipe is employed in water distribution systems. Insulated flanges are used in the plants to protect against galvanic corrosion.

Economics

Through experience, capital costs have been worked down to a very reasonable level. A one-pump injection plant, complete with water supply well, can be constructed for less than $40,000 in most instances. Plant operating costs will seldom exceed eight mills per barrel of water injected.

Prudent operation of an average Western Nebraska waterflood project should provide weighted average net working interest profits on the order of $1.70 per gross bbl of secondary oil.

★ ★ ★



Next time try a Baroid Mud Program

Baroid has reduced the element of chance and increased the element of success in *your* drilling mud program by integrating *every* step of production, distribution, and engineering application into a single chain of service. Oil companies and contractors who use this sensible plan know that such streamlining produces marketing efficiency.

When a single set of high standards are applied to every step, the end result is lower drilling costs and better completions. Baroid's mining, manufacturing, quality control, new-product research, warehousing, delivery and engineered application are maintained at the exacting level you expect.

Only through such coordination can uniform standards be extended from a local or regional level to one of national or international scope. In product quality, dependable delivery and engineering skill, you get Baroid excellence whether your well is near Coalinga or Casper; Corpus Christi or Crowley; Caracas or Calgary. *You save drilling dollars* with a Baroid Mud Program!

BAROID

BAROID DIVISION NATIONAL LEAD COMPANY

MAIN OFFICE: P. O. BOX 1675, HOUSTON 1, TEXAS

6046

Proper preparation will . . .

Make Your Drillstem Test a Success

The drillstem test is a valuable tool in preliminary formation evaluation . . . if it is reliable . . . and just a little extra preparation will greatly increase the odds for a successful test

G. E. Wilson, *Johnston Testers, Inc., Victoria, Texas*
and
J. R. Holmes, *Johnston Testers, Inc., Houston, Texas*

MANY DRILLSTEM TESTS, so vital to primary formation evaluation, are unsuccessful simply because the well has not been properly conditioned prior to the test. You might ask just what is meant by "proper preparation for drillstem testing." Basically, this preparation should consist of the necessary steps to assure that the mud is of the right viscosity and weight, and that it is clean and free from loose material. Also, you should know the water-loss properties of the mud and the condition of the hole itself.

One of the principal limitations to open-hole testing has been the lack of a properly planned program to include complete well preparation prior to testing. Why is so much emphasis placed on conditioning and preparation? Simply, it pays off. Good conditioning means (1) fewer misruns, resulting in a saving in rig time; (2) better test results indicated by good pressure charts, smoothly operating tools, and elimination of tool plugging; (3) greater safety factor eliminating some chances of blowout, lost circulation, and stuck drill pipe; (4) a better and truer formation sample. Fully 50 percent of all failures to obtain a successful and conclusive test are caused by the condition of the hole and improperly conditioned fluid.

What Causes Misruns?

In open-hole testing, the major cause of misruns is tool plugging, which may be due to several causes:

a. Improper preliminary circulation may fail to remove cuttings from the hole.

b. Bridging makes it necessary to force the packer through the bridge, pushing the debris to the bottom of the hole opposite the zone to be tested. When the test-tool valve is opened, this same material enters first and has a tendency to plug the perforated anchor and orifices in the testing tool. Even though the anchor or testing valve does not plug completely, the heavy material will obstruct the free entry of fluid into the tester and drill pipe.

c. If the drilling fluid is improperly prepared, the junk and suspended particles will settle out, filling up the bottom portion of the hole and possibly resulting in packer setting too high, not testing the desired interval, and complete plugging of the anchor openings or test-tool orifices.

Another cause of misruns in open-hole testing is packer seat failure:

a. When circulating to condition mud, improper circulating procedures can easily wash out the intended packer seat.

b. If testing is done in a large-gage hole, chances of having a good packer seat are less than in a reduced rathole.

In casing testing, the hazards are lessened by virtue of having a good packer seat. However, casing misruns can be caused by such factors as:

a. Tool plugging resulting from junk in the hole or improper fluid properties, lost-circulation material, etc.

b. Cement coating or burrs in the pipe resulting in failure of the packer to seat properly.

c. Pieces of cement or junk in the fluid settling out and preventing a good packoff by the packer; suspended material can prevent the slips from getting a good bite when the packer is set.

In order to prevent misruns and erroneous information as described, a program of proper well and fluid conditioning is recommended before the tester arrives on the scene.

Recommended Preparations

In open-hole work it is recommended that the drilling fluid be of sufficient weight to control the pressure of the producing zone, and the viscosity low enough to maintain fluidity. If mud weight is too low, there is risk of a blowout after the test is over. If viscosity is too high, there is the possibility of losing circulation by breaking down the formation from the pressure exerted by running the packer in the hole, as well as increased danger of plugging the tool during the test.

Water-loss characteristics of the fluid should be watched carefully to prevent filtration of considerable fluid into the formation to be tested. This could cause a skin effect in the bore and block off the producing formation, giving a false test. If the fluid has a high water loss and a heaving type shale is drilled, the shale will absorb water, swell, and slough into the hole and possibly stick the packer or drill pipe.

Before pulling out of the hole to make the drillstem test, circulation should be maintained for a sufficient time to insure the removal from the hole of cuttings and heavy viscous mud which will interfere with the entrance

Presented at the Spring Meeting of the Southern District, Division of Production, American Petroleum Institute, San Antonio, Texas, March 16-18, 1960, under the title "Proper Preparation for Drill Stem-Testing."

of fluid into the tester. In many instances, an extra hour consumed in circulating the drilling fluid will save five or six hours of rig time that would otherwise be spent in making an unsuccessful trip in the hole with the tester. In open hole, while circulating, it is good practice to raise and lower the drill pipe intermittently to prevent a concentration of fluids on one formation, or spot, causing a washed-out packer seat. While circulating, the mud should be run through a shale shaker to extract all cuttings and foreign bodies.

When preparing for a casing test, the fluid, of course, should be circulated in the well to be absolutely sure that all junk and foreign particles in suspension are removed. Whenever possible the fluid should be run through a shale shaker. Where a serious case of junk or large-particle suspension is encountered, it might be desirable to reverse-circulate. This would wash the junk or particles to the bottom of the hole where they would either settle out or be carried to the surface by high fluid velocity inside the drill pipe or tubing. This would help to eliminate the tool-plugging problem. As mentioned previously, burrs from old perforations and cement scale on the inside of the casing can cut up a packer rubber, damaging it to the extent that it will leak after setting. Also cement scale might drop off after the packer had passed and settle on top of the packer, causing it to stick.

Cement on the inside of the casing might clog the packer slips, causing poor bite characteristics. To eliminate this problem, a casing scraper should be run on the last round trip prior to the drillstem test and while conditioning fluid. The casing scraper also will make a clean surface for the packer slips to bite into and a smooth place for the packer rubbers to pack off.

When planning to make a full-bore test where a recorder section must be reversed out, the tubing should be rabbited to remove such obstructions as cement in joints, bent pipe, mashed pipe, and junk.

Safety measures should be taken, such as checking blowout preventers, connecting water to engine exhausts to prevent flashing during the test, directing mud guns on the derrick floor for use in event of fire during test, checking electrical wiring for gas-proof lights and bad connections, stressing "no smoking" on the rig, and all normal safety regulations dictated by good drilling practices.

What Does It Cost?

In conclusion, it is emphasized that, because of the extremely high costs of labor and material in drilling operations, it would behoove the drilling concern to be absolutely sure that all possibilities of accident and wasted time are completely eliminated. The experience of most drillstem testing companies indicates that the chance of a misrun in a poorly prepared hole is approximately 30 percent, whereas the chance of a misrun in a well-prepared hole has been cut down to roughly 15 percent. Spending an extra three hours in circulating time could well save the driller the cost of an extra round trip out of the hole resulting in an expenditure of 6 to 10 hours time. As an illustration, let us take a typical open-hole test at a depth of 7000 to 8000 ft, using a rig costing $60 per hr. In a well-prepared hole, the expenses might run as follows:

Circulation time, 3 hr	$180.00
Going into hole, 3 hr	180.00
Cost of successful test (approx)	410.00
Rig time while testing, 3 hr	180.00
Coming out of hole, 2½ hr	150.00
A successful test	$1100.00

In a hole with no conditioning or preparation, the following misrun might be encountered:

Going into hole, 3 hr	$180.00
Cost of misrun	80.00
Rig time while testing, 3 hr	180.00
Coming out of hole, 2½ hr	150.00
Total cost — lost	$590.00
Cost of re-run for a successful test	1100.00
A successful test	$1690.00

From these figures, it can readily be seen that it is possible to spend over 50 percent more than the cost of a successful test by neglecting that all-important pre-test conditioning of the hole.

In the event that the drill pipe or a packer becomes stuck in the hole due to improper preconditioning, the cost can be increased by enormous proportions by the expense of adding fishing operations required to free the stuck drill pipe. This would also apply to a packer being stuck in the casing due to improper conditioning. The loss can even amount to the entire rig because of a blowout resulting from improper mud-preparation practices. It sounds reasonable to spend $180 to save $590 and bring the productive life of the well that much closer. That little bit of preparation will pay off. ★ ★ ★

Balanced Trailer Rig Has 500 hp Engine, Can Pull Casing to 20,000 ft Depths

New trailer rig carefully balanced for weight distribution and powered by a 500 hp engine has been purchased and was recently demonstrated by Fred Hintz Oil Well Servicing Company near Dickinson, Texas. Rig services tubing to 20,000 ft depths, and it is recommended for drilling in the 6000 ft range with 4½ in. drill pipe.

Unusual features are that no external guylines are required, the fabricated truss-type trailer is lighter in weight and has a lower center of gravity when moving on the highway. Mast has a hook-load capacity of 250,000 lb, and the rig also features the new block and hook combination developed by the builder, Wilson Manufacturing Company.

It is one of four Wilson rigs operated by Hintz, some of which are trailer-mounted and others self-propelled.

Trailer rig has a 102 ft hydraulically erected and telescoped fabricated mast. Drawworks has a 42 in. water circulating brake ring and a 15-in. double hydrotarder mounted in front of the drum.

Included with the rig is a 15-ft ramp type substructure, the latest blowout preventer and other equipment.

Wilson Mogul 42 Trailer Rig has 102 ft hydraulic mast.

available through your supply store

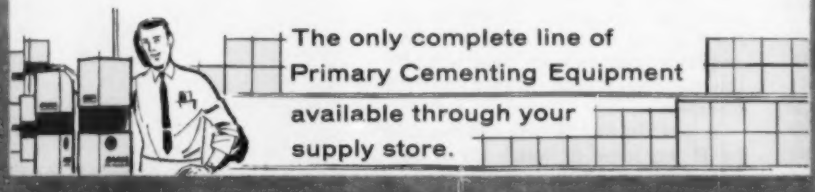
BAKER PRIMARY CEMENTING EQUIPMENT

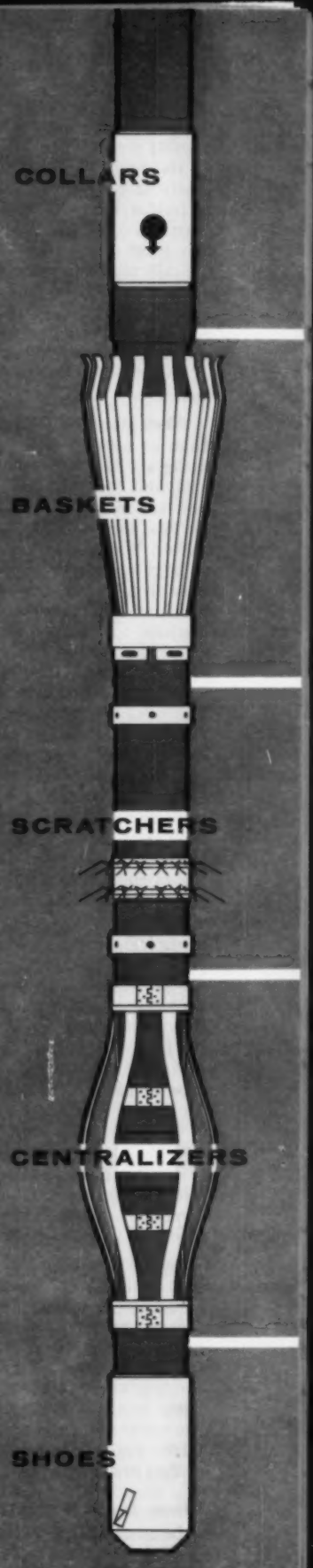
Here are all the products needed for the first step toward profitable production. Look at the variety of Shoes and Collars... Baskets... Wall Scratchers... Casing Centralizers... in every type and size to meet your well conditions successfully and economically.

Never before has your supply store been able to offer such a complete line of Practical and Dependable BAKER Primary Cementing Tools!

You get *more* than just a good cement job when you select the balanced combination of Baker Primary Cementing Equipment. For, whether yours is a routine cement job or a "problem" with weak porous zones which must be protected from dangerous pressure surges—you'll get the job done right and preserve maximum productivity.

Baker Primary Cementing Equipment is conveniently available at your supply store, backed by the stocks in 64 Baker Branches. Over 400 Baker Servicemen stand ready to provide genuine help with your cementing problems.



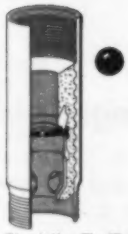


Baker
Oil Tools
Inc.
Houston
Los Angeles
New York

BAKER

Differential
Fill-Up Collar
Product No. 1091 M&F

Flexiflow
Fill-Up Collar
Product No. 161 M&F



Circulating Flexiflow
Fill-Up Collar
Product No. 161-D M&F

Cement Float Collar
Product No. 101 M&F

Cement Baffle Collar,
with Hole
Product No. 104 M&F

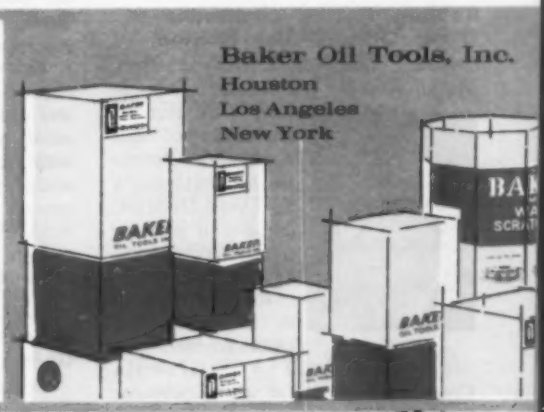
Cement Baffle Collar,
Solid
Product No. 105 M&F

Triplex
Flapper Valve
Float Collar,
Product No. 134 M&F

Metal Petal Basket,
with Stop Rings
Product No. 343

Plain Hook-Up Nipple
with Metal
Petal Basket
Product No. 330

Avoid welding . . .
lock casing shoes
and collars with
BAKERLOK
Thread-Locking
Compound
Product 050



Hinge-Lok Wall
Scratcher, with
4½" long wires
Product No. 900-C

Hinge-Lok Wall
Scratcher, with
2½" long wires
Product No. 900-C

Solid-Ring Wall
Scratcher, with
4½" long wires
Product No. 901-C

Solid-Ring Wall
Scratcher, with
2½" long wires
Product No. 901-C

Hammer-Lok
Stop Rings
Product Nos.
940-B (Solid)
and 945-B (Hinged)

Rotating
Wall Scratcher
Product No. 903

"G-12" Slim Hole
Casing Centralizer
Product No. 910-G

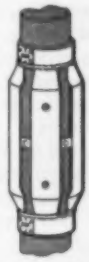
"HN-15" Solid-Ring
Casing Centralizer
Product No. 908-HN

"HN-20" Solid-Ring
Casing Centralizer
Product No. 908-HN

"H-15" Hinge-Lok
Casing Centralizer
Product No. 9115

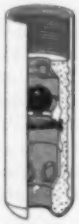
"H-20" Hinge-Lok
Casing Centralizer
Product No. 9112

"H-25" Hinge-Lok
Casing Centralizer
Product No. 9113



Hinge-Lok Rigid
Casing Centralizer
Product No. 9133

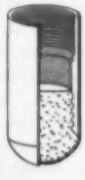
Differential
Fill-Up Shoe
Product No. 1081



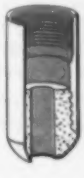
Flexiflow
Fill-Up Shoe
Product No. 160

Cement
Float Shoe
Product No. 100

Cement Wash-Down
Whirler Float Shoe
Product No. 120



Cement
Bull Plug Shoe
Product No. 103



Cement Guide Shoe
Product No. 102

Triplex Cementing Shoe Product No. 1363

Capsule Summary . . . of API Southern District of Production Meeting

Meeting highlighted advances in drilling, completion, and production practices, with emphasis on South and Southwest Texas conditions. It was held March 16-18 at the Hilton Hotel, San Antonio, Texas.

Robbins Elected Chairman, Other Officers Also Named

Jack P. Robbins, division manager in San Antonio for Skinner Corporation, was elected chairman of the American Petroleum Institute's Southern District, division of production, March 18, in San Antonio, Texas.

Jack P. Robbins

Robbins replaces A. L. Vitter, Jr., chief engineer for The California Company in New Orleans, Louisiana. Vitter was elected chairman of the district advisory committee.

Paul Clinkonbeard, of the Dow Chemical Company's Dowell Division, Shreveport, was elected to the district secretary-treasurership. He succeeded Robert A. Bushman, Field Drilling Company, San Antonio, Texas.

Blowout Prevention

Oil well blowout prevention depends as much on management's determination and the training of drilling crews as it does on preventive equipment and procedures, T. B. O'Brien, Gulf Oil Corporation, Houston, Texas, stated. Management, said O'Brien, should not be so economy-minded as to begrudge time spent on crew training or on periodic testing of prevention equipment.

O'Brien's report, which was co-authored by W. C. Goins, Jr. of Gulf's Pittsburgh staff, declared that prevention measures were unsatisfactory if over two and one-half minutes were required to apply all preventive procedures.

Commissioner Dies

John B. Hussey, 52, a Federal Power Commissioner, suffered a heart attack and died while being introduced as a speaker at the Southwest District API meeting.

He had accepted the presidential appointment to a five-year term on the FPC and resigned his position as Louisiana commissioner of conservation in June, 1958. Previously, he had practiced law in Shreveport, Louisiana, specializing in oil and gas law and taxation.

Fighting Paraffin Deposits

A new method of combatting oil well paraffin deposition was outlined by C. F. Parks, Dowell Division, Dow Chemical Company, Tulsa, Oklahoma. This method provides for formation of a water-wet film to which paraffin will not adhere on the surfaces of well equipment.

This inhibition is obtained with chemicals which are placed in the well and can prevent paraffin blockage for many months, Parks said, compared with frequent shutdowns for cleaning when solvent chemicals are used. New process depends for success on a thorough cleaning of the metal surfaces, including paint removal, before the inhibitor coating is applied.

Slim-Hole Drilling Giving Cost Reductions

Utilization of slim-hole drilling techniques in conjunction with turnkey features has provided Mississippi operators with a cost-reduction tool for both wildcat and development wells, J. W. Arnold, Woolf and Magee, Inc., Tyler, Texas, said.

Growing acceptance of slim-hole and tubingless completions has accelerated the need for more economical drilling practices to fully exploit savings available in this field, he said.

Gulf Coast Mud Practices

Lime-treated muds have been replaced by gypsum-treated muds as the type favored for deep wells, and surfactants are being used widely for various applications in addition to those for which the products were first proposed. These views were expressed by K. D. Tanner and George R. Gray, Baroid Division, National Lead Company, in a survey of current mud practices in drilling on the Texas Gulf Coast.

Turnkey Drilling

In a review of turnkey drilling in South Texas, Walter Kalteyer of Hunt Drilling Company, Corpus Christi, Texas, said that by this means the operator avoided the necessity for a large technical staff and was freed of the necessity of supervising the drilling.

Nonetheless, he said, many South Texas contractors were not interested in this type of contract at any price, because operators might feel preyed upon if risks which they had paid the operator to assume did not materialize.

However, Kalteyer implied, there was a prospect of increased usage of modified turnkey contracts whereby certain limits were placed on the contractor's responsibility for supervision and liability for certain costs.

Progress in Dehydrators

Progress in extraction of hydrocarbon liquids from gas-condensate wells was reviewed by R. C. Visser and H. W. De Yarmett of Shell Oil Company, New Orleans, Louisiana. These authors described a new type of dehydrator which does not require the 1000 psi pressure drop necessary in low temperature separation units and which features a shorter cycle of dessicant regeneration. The new units, in capacities from 5,000,000 to 24,000,000 cu ft of gas per day, cost from $30,000 to $140,000. Increased liquid recoveries by the units repay in one to three years the additional cost as compared to low-temperature units, the speakers stated.

Award recipients, left to right, at the API Southern District Meeting were Tom W. Keating, drilling consultant, Dallas; Jack P. Robbins, Skinner Corporation, San Antonio; L. E. Fitzjarrald, API vice president for production who made the presentations; Ben F. Carter, Union Producing Company, Shreveport; C. H. Taylor, Shell Oil Company, Houston; and Roy Bobo II, Houston, receiving for his father, Roy A. Bobo, Southeastern Drilling Company, Comodoro Rivadavia, Argentina. They received Citations for Service for outstanding service in API assignments.

Running Report . . . API Mid-Continent District Meeting

Over 600 oilmen registered for the annual Mid-Continent district production division meeting March 30, 31 and April 1.

Committee meetings were held most of Wednesday, March 30, to report and discuss a wide range of Mid-Continent area drilling and producing problems. Reports were made on drilling fluids, straight-hole drilling, high tensile-strength drill pipe, blowout preventer installations, and air or air-aerated mud drilling practices.

Production practices committees reported on secondary recovery and pressure maintenance, formation evaluation, tubing tension in pumping wells, analysis of oil field waters, declining and productivity indices.

The supervisory development committee also gave a report of wide interest and four papers were presented during this first day discussing waterflooding and a new method to increase rock bit life.

In the general session, March 30, Dr. George H. Fancher, vice president of Sinclair Research Laboratories, outlined in forceful terms the present and future challenge to exploration and production research groups. They must provide every assistance possible to help operating personnel get into everyday operation all presently known and proved advancements in techniques and equipment.

Dr. Fancher enumerated and further explained how a good production research program benefits a company's operations in at least four ways:

1. An increase in the recovery of oil from reservoirs, old or new.
2. Increase in well effectiveness.
3. Decrease in operating costs.
4. Refinement of decision-making ability.

The morning session was concluded with an optimistic address by the Honorable George Docking, governor of Kansas and chairman, Interstate Oil Compact Commission, Topeka, Kansas. Governor Docking spoke on the topic, "Oil, Its Problems and Responsibilities."

Thursday afternoon and Friday sessions were devoted to papers on drilling, producing, and management-development subjects of current interest.

John D. Albright, Cities Service Oil Company, Bartlesville, Oklahoma, was elected 1960-61 district chairman of the API Mid-Continent district, division of production. Vice-chairmen are John Dailey, Humble Oil & Refining Company, Seminole area; O. C. Atkinson, Cities Service, Kansas area; Herman Moss, M&M Oil Well Service Company, Drumright area; Frank Storm, Jr., independent, Texas Panhandle area; C. T. Asay, Pan American Petroleum Corporation, Southwestern Oklahoma area; W. F. Root, Phillips Petroleum Company, Southwestern Oklahoma area; D. H. Winchell, Sohio Petroleum Company, Golden Trend area; Trecka R. Jones, Gulf Oil Corporation, Oklahoma City area. Doug Johnson, Johnson-Fagg Engineering Company, was elected secretary-treasurer.

John D. Albright

Recipients of Citation for Service award for the API Mid-Continent district, division of production were, left to right, E. E. Young, Sohio Petroleum Company, Oklahoma City; W. B. Belknap, Phillips Petroleum Company, Bartlesville, Oklahoma; L. E. Fitzjarrald, vice president, Phillips Petroleum Company, who presented the awards; C. E. Rawlins, Phillips Petroleum Company, Bartlesville, Oklahoma; and Wayne C. Moody, Sunray Mid-Continent Oil Company, Midland, Texas. All gave outstanding service.

Log Analysts Society Meeting

The first annual meeting of the Society of Professional Well Log Analysts will be held May 15, 16 and 17 at Hotel Tulsa. Frank S. Millard, president, has announced the logging symposium program which covers many phases of exploration and formation evaluation utilizing well log information. Registration and a business meeting will be held Sunday, May 15, with the symposium starting Monday at 10:00 a.m.

Monday's Program

Introductory Remarks . . . Wm. B. Belknap, Phillips Petroleum Company.

Log Analysts Are Important People . . . M. W. Haas, Humble Oil & Refining Company.

A Review of Fundamental Nuclear Physics Applied to Well Logging . . . Joe D. Owen, Phillips Petroleum Company.

Exploration for Petroleum Traps Using Rocky Mountain Electric Log Evaluation . . . Bob Jones, Consultant, Casper, Wyoming.

Use of Flowing Well Logs in Solving Production Problems . . . Harvey L. Bryant, Jersey Production Research Company.

Accuracy of Porosity Determination . . . Ralph E. Jenkins, Core Laboratories, Inc.

Tuesday's Program

Introduction of the Society of Professional Well Log Analysts Officers . . . F. S. Millard, Humble Oil & Refining Company.

Applications of the Proximity Log . . . Robert G. Hamilton, Consultant, Tulsa.

A Method of Off-Location Quantitative Mud Analysis for Hydrocarbons . . . Wendell H. Russell, Baroid Division National Lead Company.

A Method for Determining Formation Permeability from Well Logs . . . Jarl P. Johnson, Kewanee Oil Company.

Resistivity-Velocity Log Evaluation of the Morrow Sand in Western Oklahoma . . . F. S. Millard, Humble Oil & Refining Company.

Field Results with Nuclear Magnetism Logging . . . Paul W. Hull, Standard Oil Company of Texas, John E. Coolidge, Byron Jackson Division of Borg Warner Corporation.

Interpretation of Dipmeter Surveys in Mississippi . . . James A. Gilreath Schlumberger Well Surveying Corporation.

OTIS PRODUCTION NEWS

Volume I, Number 2 **Otis Engineering Corporation • Dallas** *Production Equipment and Services*

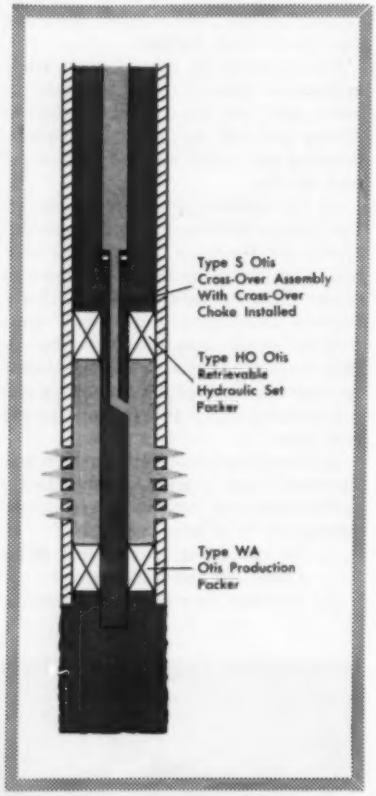
Otis 'Packaged' Well Completion Service Proves Solution To $80,000 Problem For Aggressive Oklahoma Operator

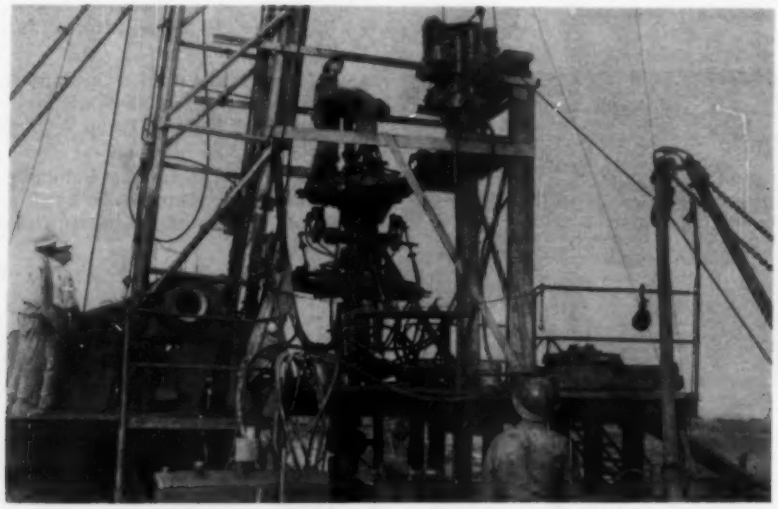
OKLAHOMA CITY — Otis well completion specialists from the Lindsay division have performed a slightly different, but basically sound, technique of completing a number of single string, dual producers for one of Oklahoma's most progressive independent operators. The wells are located in a new field being developed by this producer.The technique is that of snubbing all downhole production equipment into each well under pressure instead of killing the well. This technique has solved a problem which cost this operator some $80,000 on one well he drilled and completed in this field by another method.

The costly problem well potentialed 400 B.O.P.D. when originally swabbed in following a down-casing well stimulation treatment. Faced with not having production equipment in the well for either zone, and a 600 P.S.I. shut-in pressure, the operator decided to kill the well with a heavy lease oil before running packers and tubing. After necessary production equipment had been installed all attempts to swab the well in again failed, as did numerous special zone-stimulation fluids and treatments during the following 2½ months. When the well was finally brought in for the second time, its daily potential was considerably less than the initial 400 B.O.P.D. All told, the well owners counted a staggering $80,000 spent to get production back. Since that time Otis has been engineering the completions for this operator and snubbing all equipment into the hole under pressure. The cost of Otis' Snubbing Service has averaged less than $2,000 per well.

The completion equipment consists of a Type WA Otis Production Packer, a Type HO Otis Hydraulic-Set Packer, and a Type S Otis Cross-Over Assembly. The WA packer is a permanent-type, wire line set production packer which is used to isolate the two producing zones. The top packer is the Type HO Otis Hydraulic-Set Tubing Retrievable Packer, which is set by pressuring up on the tubing after first landing a special setting tool in the cross-over assembly made up in the packer.

In this type of installation the top packer is tested by bleeding off pressure in the casing. As engineered by Otis, this completion permits the lower zone to be produced through the annulus and the upper through the tubing — saving the cost of a second string of tubing and a dual packer — and at the same time affords a full-opening tubing string for obtaining bottom hole pressures, etc. The flow pattern of the two zones may be reversed if desired simply by changing chokes in the cross-over assembly.





Shown here are trained Otis service specialists rigging up to snub production equipment into a well under pressure. All equipment is hydraulically operated and well pressure is under control throughout the entire operation

The technique of snubbing pipe and downhole production equipment in and out of oil and gas wells under pressure was developed by Otis 32 years ago. It has proved its economic advantages — as in the case of this operator — time and time again. The work is done by trained Otis specialists with unparalled experience in this type of work. For a detailed description of Otis' Snubbing Service, and the packers and cross-over equipment used in these wells — or for help with any of your well completion problems, call the Otis office nearest you or write Otis, Dept. 2-P, Box 35206, Dallas 35, Texas. Experienced Otis specialists are ready and anxious to provide you with a "packaged" well completion service.

©1960 O.E.C.

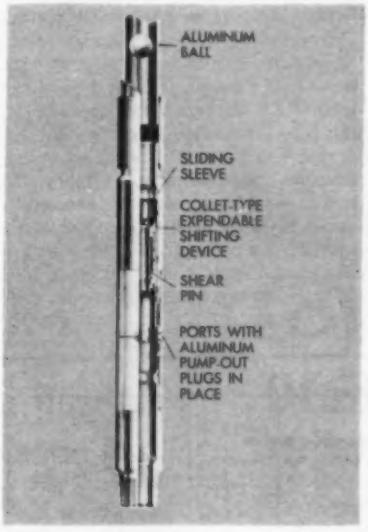
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Better Production Tools Through Research

New Otis Tool Provides Additional Blowout Protection—Cuts Completion Costs

BELLE CHASSE — Operators in this area are using a new version of the Type A Otis Sliding Side-Door to complete their high pressure wells with greater safety and economy. This tool permits them to run high differential type drillable packers and nipple up the tree before unloading the well during completion operations. This makes possible a completion technique which allows the operator to keep his well under control throughout the entire operation. It also eliminates the need of having a wire line service unit on location and the problems encountered when performing wire line work in heavily weighted fluids.

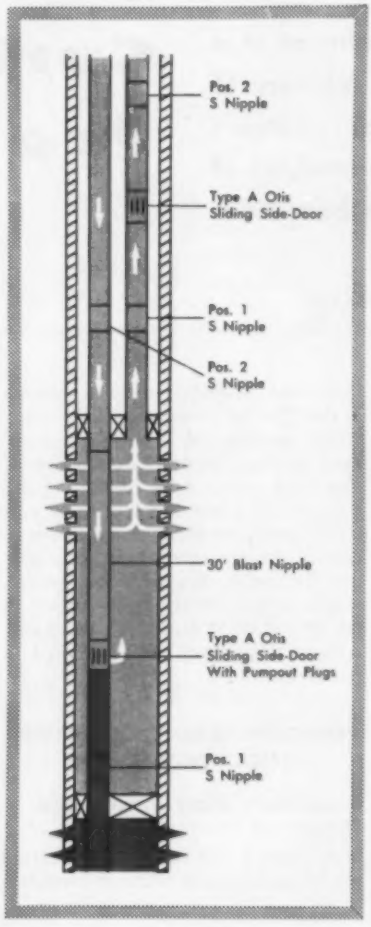
This new version of the Otis Sliding Side-Door is designed to be run into the well on the tubing with the sleeve opened. Tapered aluminum plugs inserted in the ports of the tool's outer mandrel serve to prevent communication from the casing annulus to the tubing until the well is to be circulated. A special collet type expendable shifting device is located in the upper recesses of the tool's sliding sleeve. This shifting device is designed to catch an aluminum ball or drop plug that is pumped down to close the side-door. (See illustration below.)



Type A Otis Sliding Side-Door with pump out plugs and expendable shifting tool in place.

The technique made possible through use of this new tool is both simple and sure. One of several ways the tool is being used is as shown in the accompanying schematic. The new model Sliding Side-Door, with special pump out plugs in the ports, is made up in the long string and located between the two packers. A standard Sliding Side-Door is located in the short string above the top packer for use at a later date. With this equipment in the well, packers may be tested by pressuring up on the short string. Blowout preventers are then removed and the tree installed with mud in the hole.

Once all provisions have been made to bring in the well, pressure is applied to the long string to dislodge the pump out


Pos. 2 S Nipple
Type A Otis Sliding Side-Door
Pos. 1 S Nipple
Pos. 2 S Nipple
30° Blast Nipple
Type A Otis Sliding Side-Door With Pumpout Plugs
Pos. 1 S Nipple

plugs and mud is circulated out of the well through the short string. Approximately 400 pounds' differential pressure is all that is required to dislodge the plugs. Once mud has been displaced, the sleeve in the Sliding Side-Door may be shifted to its closed position by pumping down an aluminum ball or drop plug. The design of the expendable shifting mechanism in the Sliding Side-Door is such that when the sleeve reaches its fully closed position the collets on the expendable shifting tool release and the shifting device can be pumped out of the bottom of the tubing. After the Sliding Side-Door has been closed, it may be reopened for circulation or production at any future date by standard wire line methods. In the closed position, both V-type packing and O-rings act to provide a positive seal between the sleeve and outer mandrel of the tool.

The Otis Sliding Side-Door, with special pump out plugs, v as designed and built to help operators reduce their costs when completing wells offshore and in inland water locations. However, the tool has proven so successful in this usage that several major companies have adopted both this new tool and completion technique as a standard operating procedure for all their high pressure wells.

Perhaps you are faced with completion and downhole production problems with which your local Otis specialists can help you. If so, call them today. For more information on the new Type A Otis Sliding Side-Door with pump out plugs or for help with any completion problem, call the Otis Office nearest you or write Otis, Dept. 2-P, Box 35206, Dallas 35, Texas. You'll find experienced Otis well completion specialists ready to help you — anxious to serve you.

New Otis Catalog Serves As Well Completion and Wire Line Service Guide

A new 116-page multicolored catalog of production equipment and services has just been published by Otis Engineering Corporation and is available upon request.

The new catalog contains drawings, operating diagrams, installation schematics, descriptive material, and complete dimensional data on more than a hundred different Otis tools — some of which have never been cataloged before. The catalog is divided into six sections to help the user find any piece of Otis equipment, or any one of their special services, easily and quickly. The sections cover Safety Equipment, Gas Lift Equipment, Completion Equipment, Post-Completion Equipment, Special Services, and Service Tools. Each section contains a concise preface describing the different types of equipment or services covered by that section and where and when the equipment or service should be used. The catalog has an index by sections, and is indexed and cross-indexed alphabetically by tool.

This new catalog will serve as the Otis section of the 24th (1960-61) Edition of The Composite Catalog, however those interested in obtaining a copy for their own personal use may do so by writing Otis Engineering Corporation, Dept. 2-P, Box 35026, Dallas 35, Texas.

OTIS

Engineering Corporation

General Offices:

6812 Denton Drive • Dallas, Texas

Effects on ultimate recovery of . . .

Waterflood Curtailment— Pro and Con

What effect does the curtailment of a waterflood have on ultimate recovery of oil? Many say "none" . . . others say "much." Here is an analysis of the arguments from both sides

Donald E. Menzie and Frank W. Cole, *University of Oklahoma, Norman, Oklahoma*

THE PROBLEM of waterflood curtailment is not new. In 1930, in Pennsylvania, a surplus of crude oil forced the oil producers of that area to restrict their producing rates. Since that time, waterflood curtailment has been considered or imposed in other operating areas. The problem has not been acute until the last two or three years, when, due primarily to a large influx of cheaper foreign oil, allowable producing rates have been reduced markedly. As the relative percentage of waterflood production to total production continues to increase, the problem of waterflood curtailment again presents itself.

For evidence of the importance of the problem, consider present Oklahoma production, where daily waterflood production is approximately 140,000 bbl, compared to a daily unallocated primary production of 156,000 bbl. On a depth basis, the unallocated production is approximately comparable to the waterflood production.

A large percentage of existing water floods are at relatively shallow depths. If these shallow floods could be curtailed without serious loss of ultimate recoverable oil, this would seem to be the desirable thing to do. On the other hand, if curtailment of these water floods would result in substantial loss of otherwise recoverable oil, then in the interest of conservation, these operations should not be curtailed until it becomes absolutely necessary.

There has been a great deal of discussion regarding the effects of waterflood curtailment. Most of the written and verbal material has been to support a specific contention. The purpose of this paper is to consider objectively the evidence on both sides of the argument, and to analyze these arguments in the light of present-day technology.

The problem of waterflood curtailment is often clouded by discussion of low rates versus high rates of water injection. If a waterflood is to be curtailed it will probably be necessary to restrict the producing rates only during the peak oil-production period, which is a relatively small period in the overall flood. It is this type of curtailment which will be considered in this discussion.

CONSIDERATIONS OF WATER FLOOD CURTAILMENT

Laboratory Experiments and Theory of Waterflooding

A survey of pertinent literature shows conflicting conclusions from laboratory experiments. Many investigators have reported results of laboratory experiments which show that cumulative oil recovery by waterflooding is not appreciably affected by rate of movement of the flood front. Other investigators have reported results of laboratory experiments which show that the rate does affect recovery.

One of the main reasons for the disagreement and the conflicting results appears to be scaling of laboratory experiments. Prior to the late 1940's, few laboratory workers considered scaling the laboratory model to the field reservoir. Even now it is probably impossible to scale completely a laboratory model with the reservoir conditions. Attempts have been made to scale the applied pressure gradients, which is not too difficult. Other attempts have been made to scale gravitational pres-

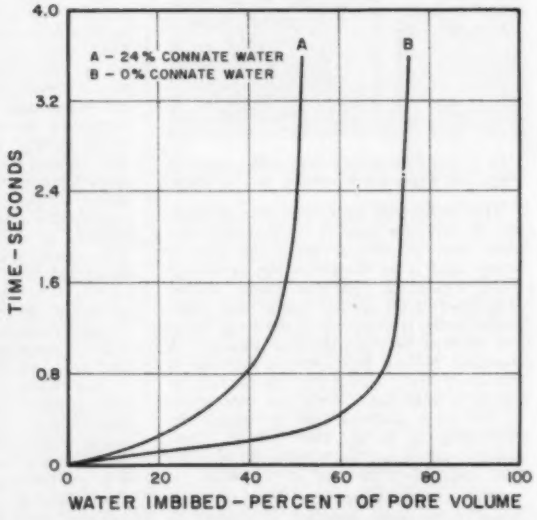
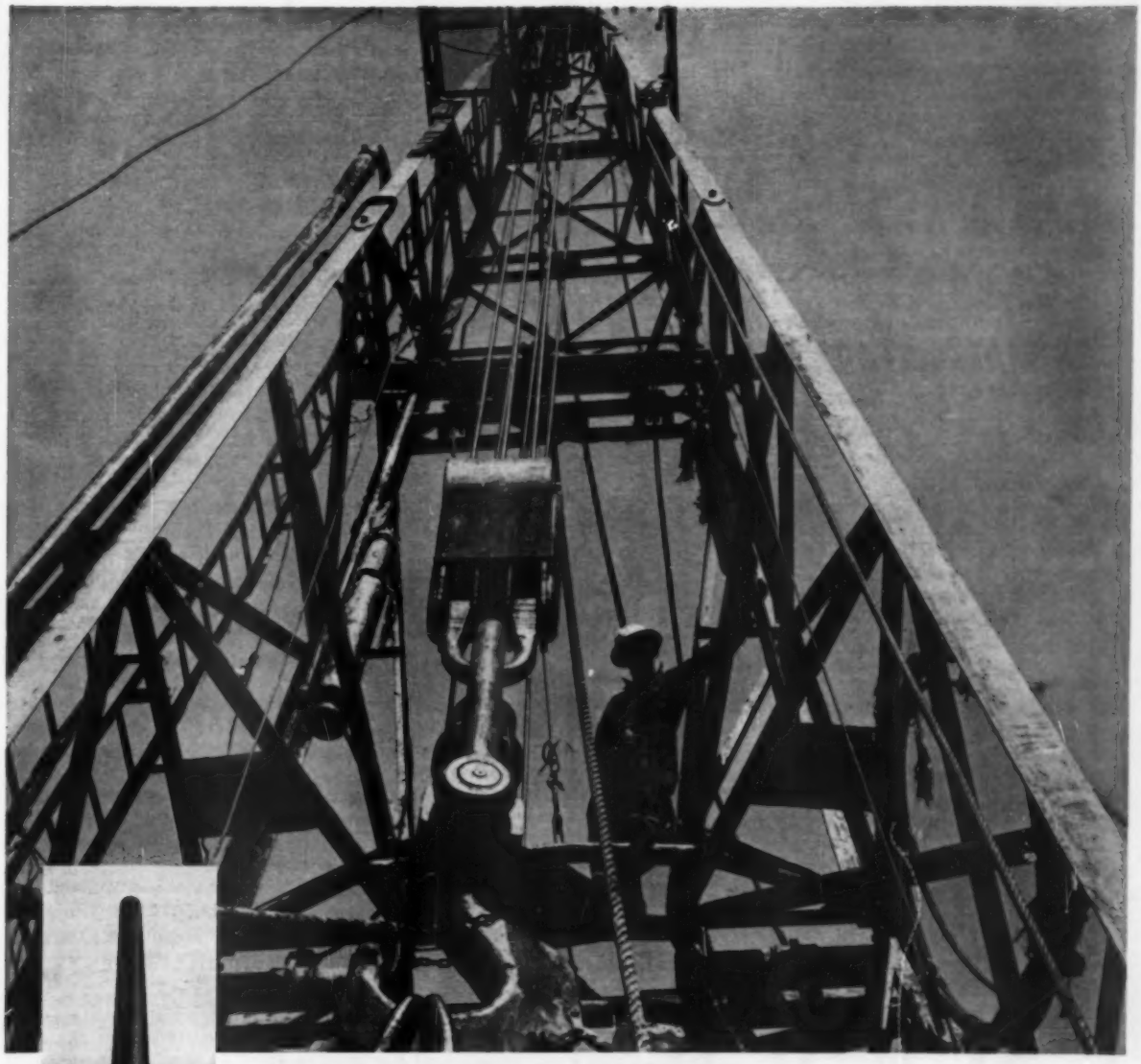
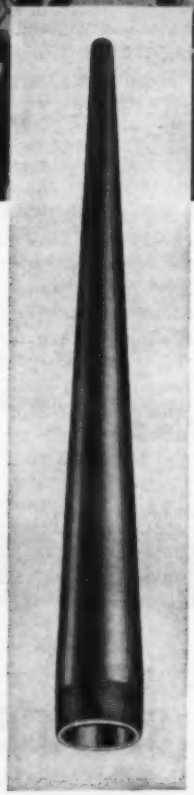


FIG. 1. Typical imbibition curve shows water imbibed into a core where (A) there is no saturation of the wetting phase, and (B) there is a partial saturation of the wetting phase.

Presented at the Third Biennial Secondary Recovery Symposium of the Society of Petroleum Engineers of AIME, Wichita Falls, Texas.





DEEPER AND DEEPER
with CF&I Seamless Casing and Tubing

The deeper wells and advanced equipment required for today's oil recovery demand the finest in casing and tubing — CF&I Seamless Casing and Tubing. The CF&I mill at Pueblo uses equipment rated among the most up-to-date in the industry. Production techniques feature unusually exact quality controls.

From its central location, CF&I Seamless Casing and Tubing can be distributed rapidly to the major oil fields. All CF&I Seamless Casing and Tubing is made to API specifications, in sizes 2⅜" to 9⅝" O.D. For full details, contact your local CF&I Sales Office or our General Sales Office, Denver, Colorado.

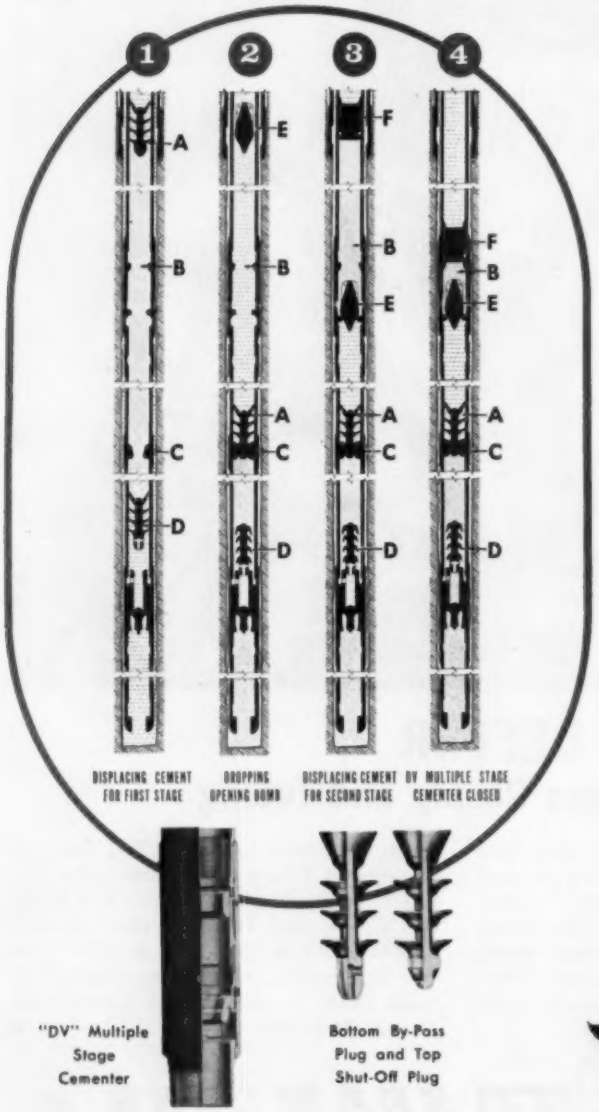
7700

CF&I STEEL **SEAMLESS** *casing and tubing* API

THE COLORADO FUEL AND IRON CORPORATION
DENVER, COLORADO

4 STEPS TO SUCCESS

IN MULTI-STAGE CEMENTING



"DV" Multiple Stage Cementer

Bottom By-Pass Plug and Top Shut-Off Plug

If you've thought of multiple stage cementing only in connection with multi-zone completions, you may be missing many benefits that could be yours by using this system in conventional primary cementing. For instance,

DID YOU KNOW THAT MULTIPLE STAGE CEMENTING CAN HELP YOU . . .

- Get better *full depth* cementing?
- Reduce cement pumping pressures and possibility of channeling?
- Minimize cement slurry loss to thieving formations?
- Pinpoint cement placement at any depth?

The schematic drawings illustrate the *Steps to Success* in multiple stage cementing developed by Halliburton over the past 30 years.

1 STEP ONE . . . Bottom By-Pass Plug (D) leads the cement, displacing well fluid ahead of it, and seats in the By-Pass Baffle located on top of the Super Seal Float Collar after passing through the "DV" tool (ports closed). Openings in the Bottom Plug allow passage of cement through the plug. Shut-Off Plug (A) follows cement and seats in its Baffle (C) to complete the first stage job.

2 STEP TWO . . . Opening Bomb (E) is dropped through casing and seats in "DV" tool (B). Pressure is applied, opening the "DV" cementing ports.

3 STEP THREE . . . Second stage cement is pumped down, followed by Closing Plug (F).

4 STEP FOUR . . . Displacing fluid pumped behind Closing Plug (F) moves the cement through the open ports in the "DV" tool until Closing Plug (F) is seated in top of the tool which closes the ports and completes the job.

"DV" MULTIPLE STAGE CEMENTER . . .
is hydraulically operated by pump pressure to open after passage of first stage cement and close at completion of second stage.

BOTTOM BY-PASS AND TOP SHUT-OFF PLUGS . . .
for first (lower) stage of job. Note openings in bottom plug to allow passage of cement through Float Collar and Guide Shoe.

Ask your nearby Halliburton Representative to explain how this experience can pay off for you.

275 SERVICE CENTERS . . . JUST MINUTES AWAY FROM YOUR WELL

HALLIBURTON CEMENTING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY • DUNCAN, OKLAHOMA

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

sure gradients with somewhat less successful results. Not many attempts have been made to scale capillary-pressure gradients.

Fluid viscosities may be scaled without difficulty, but such effects as wettability of the reservoir solids and identical distribution of fluid saturations have presented difficult problems.

As a result of the difficulties in scaling, most laboratory experiments have not exactly duplicated reservoir conditions. The degree of duplication seems to influence directly the results and to cause a great deal of the variation in results of the effect of rate.

When all the published laboratory data are examined and reviewed in light of recent developments of laboratory techniques and theory, the following conclusion appears to be indicated. In a homogeneous porous medium of uniform wetting characteristics and linear-flow conditions, recovery of oil appears to be independent of rate. In other words, if all laboratory experiments were scaled, if all above restrictions were considered, if special "end effects" or capillary effects were removed, if all models or cores for laboratory experiments were constructed to eliminate all special edge effects or skin effects, then oil recovery apparently would not be influenced by the rate of water advance in a water flood.

Theoretical considerations of relative permeability indicate that relative permeability is also independent of the rate of flow of oil and water. Early laboratory experiments were not in agreement on this lack of effect of rate, but the laboratory experiments in most of those cases did not take into account boundary effects, hysteresis effects, wettability changes, and other special effects due to the laboratory model or core shape, size, or composition. There are enough laboratory data reported to indicate that oil and water relative permeability is not dependent on rate of flow.

Wettability

One of the major reservoir engineering problems at present is determination of the true wettability of a reservoir. As more is being learned about the nature of polar compounds found in many crude oils and the effects of these polar compounds on the surfaces of the different rock materials in altering wettability, the conclusion that most reservoirs are totally water-wet is less firm.

Those advocating proration of water floods often cite the importance of increased waterflood recovery to be obtained by reducing flooding rate to take advantage of imbibition or capillary effects which promote oil recovery. These proponents of waterflood curtailment reason that as the displacing water moves faster in the more permeable layers of a heterogeneous reservoir, if water is the wetting fluid, water will be imbibed from zones of high water saturation in the more permeable layers to zones of low water saturation in the low-permeability layers. This will cause a dual result. Oil will be displaced out of the low-permeability layers and some of the water traveling at a relatively high velocity in the more permeable layers will be removed, thus effectively slowing the velocity of the flood front in the more permeable layer. It is claimed that this would tend to increase oil recovery, and the effect would be greater at the lower rates.

At least one waterflood operator believes that many field water floods may be imbibition controlled, in which case the application of external pressures could have little effect, although there are apparently little field data to substantiate this. At the University of Oklahoma some laboratory experiments on large sandstone cores appear to lend some support to this theory.

Although a similar end result is also postulated for oil-wet reservoirs, this situation will not be reviewed, because many people are in agreement at the present time that few, if any, oil reservoirs are oil-wet.

With reservoirs of intermediate wettability, effects of wettability and imbibition become more complex, and a simple solution is not available. However, situations can easily be visualized where no imbibition would take place, in which case the wettability of the reservoir would have little or no effect on oil recovery at different flooding rates.

Where a partial saturation of the wetting phase is present as, for example, an interstitial water saturation in a water-wet reservoir, the rate of imbibition will be much less than the rate of imbibition of a wetting phase into a porous medium where there is no saturation of the wetting phase. This is to be expected from an analysis of the wetting-phase fluid distribution in a porous medium. Fig. 1 shows imbibition of a wetting phase into a core where (A) there is no saturation of the wetting phase, and (B) there is a partial saturation of the wetting phase. Unfortunately, at the present time it is probably impossible to determine the magnitude of these imbibition effects in an actual reservoir.

Cumulative Oil Production Curves

Several water floods have been analyzed by presenting data concerning cumulative oil produced and cumulative water injected, in an attempted evaluation of waterflood performance. Such cumulative data and curves are notably insensitive to slight changes in the data. Using cumulative curves it would be almost impossible to show an effect of a slight change in rate either of water input or oil production. Thus, presentation of this data cannot prove or disprove the question and only tends to confuse the issue.

Voluntary Curtailment by Flowing Waterflood Production

One source of information on the question of the effect of pressure or rate changes on recovery of oil in waterflooding should be from the field results obtained in cases of flowing waterflood production. Flowing production in waterflooding is another form of imposing a back pressure on the producing well. Unfortunately, in most flowing waterflood projects total recoverable oil production is so closely related to the economics of the flood that it is almost impossible to conclude whether more or less oil was obtained by the application of the back pressure on the producing well. Flowing operating costs are usually lower, and thus the economic limit for any well or lease is extended. It would be expected that some additional oil could be produced by flowing over the longer economic life of the property.

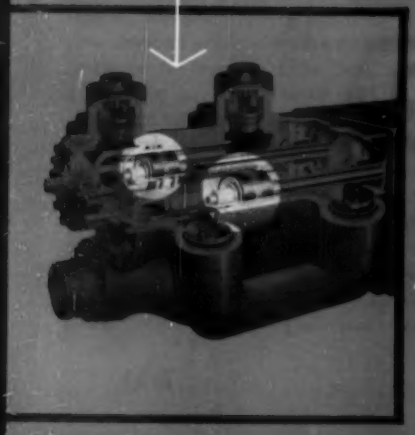
Comparison With Natural Water Drives

Waterflood operations have often been likened to natural water drives, where it is well established that slow rates of oil production will increase ultimate recovery. The physical displacement processes of waterflooding and of natural water drives are probably identical, as there should be no difference in the displacement of oil from individual pores in the reservoir rock.

There are, however, two fundamental differences in natural water drives and pattern waterflooding: (1) In a natural water-drive reservoir, the water underlies the oil zone, and high rates of production will promote water-coning into the producing interval, with probable loss of ultimate oil recovery; and (2) Slower rates of production permit maximum edge-water encroachment with less rapid decline of reservoir pressure, which will also increase ultimate oil recovery. Therefore, although the displacement processes are identical, due to the differences in the relative locations of the oil and water zones natural water-drive reservoirs and secondary-recovery water floods

the name Mission here

is your guarantee of real savings here



Take a good look at this Mission piston. Mission was first with this design, although today you'll see other pistons made to look like it. You see, the engineering advances that have gone into Mission pistons have made them the standard by which all others are judged.

Replaceable rubbers, long-life rubber compounds, special fabric backing, one-piece forged steel bodies, hardened piston flanges, close tolerances, wear groove in piston body flanges, API taper for piston bore, and easy and reliable snap rings and end plates are some of the specific reasons Mission pistons are superior.

The unique Mission guarantee, that Mission products will outperform any other products, is the big reason that removes all chance. You get the best only from Mission; so got only Mission—genuine Mission with the name on them—pistons. Play it safe!

MISSION MANUFACTURING CO.

MISSION MANUFACTURING CO., P. O. Box 4200, Houston, Texas, cable address "MISSCO" • export office: 30 Rockefeller Plaza, New York. In the United Kingdom: MISSION MANUFACTURING CO., LTD., 1 Hanover Square, London W. 1 England • cable address "MISSCOMAN"

69—593

TAKE PROBLEMS OUT OF PRODUCTION WITH THIS SIMPLE FORMULA

In other words the advanced Brown HS-16-1 hydraulically set packer in your well EQUALS profit plus.

It's simple arithmetic—packers produce either more profit or less. The Brown HS-16-1 will produce more profit because it was designed to solve more production problems.

It's easy to work out your own solution. Check the advantage chart for extra profit possibilities on your next completion.

A. Multi-purpose HS-16-1 can be used for all these applications:

A1. As a packer for single zone completion.

A2. As a packer for single-string dual completion.

A3. As the lower packer in a multiple-string completion.

A4. As the packers (any number in the same well) for multiple alternate-zone installations.

A5. An excellent packer where acidizing or fracturing is being done. Dual slips enable the packer to withstand high differential pressures – pressure exceeding tubing limit.

B. Going in – the HS-16-1 offers these advantages:

B1. Savings in rig time while running and setting. Ample by-pass area allows free flow of well fluid around the packer.

B2. Circulation with the well head in place, and before setting the packer eliminates wire line work.

B3. The HS-16-1 is easily run in straight or deviated holes.

B4. No difficulty in running the packer into the top of a liner.

C. Setting the HS-16-1 is a simplified operation:

C1. No tubing manipulation necessary to set packer.

C2. Design eliminates the possibility of premature setting.

C3. The "hydraulically-set" feature minimizes the problem of spacing out.

C4. Positive well control is achieved since the well head is installed *before* the packer is set or drilling fluid displaced.

C5. Producing zones may be washed *after* the well head is installed.

C6. Set at any depth as no tubing weight is required when setting. Hydraulic setting allows the tubing to remain in tension due to its own weight.

C7. Treating fluid may be spotted across the producing zone before the packer is set.

D. Coming out – the HS-16-1 has two big advantages:

D1. A fully retrievable packer, the HS-16-1 can be rerun after servicing. The cost of drilling and replacing a permanent-set packer is eliminated.

D2. Swabbing action while pulling is minimized by the built-in equalizing valve and the ample by-pass area around the packer.

The Brown HS-16-1 packers are available in all popular sizes or to your specifications on special order. Just call one of our representatives—they serve production areas throughout the free world.

BROWN OIL TOOLS, INC.

8490 KATY ROAD P. O. BOX 19236,
HOUSTON 24, TEXAS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

should not be compared directly when studying rate effects.

Permeability Variations

One of the principal arguments of those opposing restriction of waterflood producing rates is that some of the zones in the reservoir will be left unflooded if injection rates become too low. The opponents of waterflood curtailment argue that field experience has shown that higher injection pressures, i.e., higher injection rates, will force water into some of the low-permeability zones which would not take water at the lower injection pressures. The pressure required to force entry into a particular zone has been referred to as "threshold" pressure. For support of this contention, reference has been made to field instances where a hydrostatic head of water in an injection well has resulted in the injection of no water. It has been noted that the application of increased pressures has resulted in injection of some water, and at still higher pressures the injection of considerably more water. The opponents of waterflood curtailment theorize that "threshold" pressure is preventing entry of water into the formation, and that as the higher permeability zones will have the lowest "threshold" pressure, then as injection pressures are increased, more lower permeability zones will be available for water intake and consequently for oil production. If this cycle of events actually happened, then during periods of reduced injection pressures the rate of advance of the flood front in some low-permeability zones could conceivably be stopped entirely.

Unfortunately, the above discussion is a theory and cannot, at this time, be proved either in the field or in the laboratory. Although it is well known that these higher-than-calculated injection pressures may in some cases be required, apparently there is no established proof that this phenomenon is due to permeability differences. It is quite possible that this condition may be due to a water block or plugging of some kind entirely unrelated to permeability distribution. In any event, if waterflood curtailment were being considered, high injection pressures could be maintained and a back pressure applied at the producing well, which would reduce this factor as a consideration.

Field Performance

The use of some type of decline curve has probably been predominant in most arguments by those opposing waterflood curtailment.

In many of the field examples of the use of decline curves, an increased injection pressure or rate produced a correspondingly favorable change in slope of the decline curve. It is difficult to prove that the favorable rate change amounted to an increased ultimate oil recovery. It is possible that the same ultimate amount of oil may be produced, but at higher rates of water injection, rates of oil production are temporarily increased. Accuracy of the decline-curve analysis is not great enough to be accepted as reliable evidence for or against the importance of the effect of rate of water injection on ultimate recovery. In general, the technique of decline-curve analysis of field data is at the mercy of the individual who extrapolates the curve, and often the interpretation is more dependent upon the type of coordinate system used than upon the actual mechanics of fluid flow.

Economics

Economics is of paramount importance in waterflooding operations, as the oil producer is not in business to produce oil, *per se*, but to make money. Reducing the rate of injection at any time during the life of the flood will result in less ultimate profit from the flood. This is caused by increased operating and maintenance costs, and the necessity for longer-life equipment. It is entirely conceivable that under proration some marginal prospects might not be flooded, due to the increased payout time. Although regulatory bodies are not concerned directly with economics, they are indirectly involved, because in order to obtain the maximum oil recovery, the economics of the situation must be sufficiently attractive to the oil operator. When considering economics of secondary-recovery operations, however, the economics of primary producing operations must not be forgotten. A satisfactory balance between the two must be maintained.

Gravity Effects in Waterflooding

In any water flood where there exists a difference in density between the oil phase and the water phase, it is generally agreed that a "tilted" water front will exist. Magnitude of this gravity segregation between oil and water will depend upon the vertical permeability and upon the number of shale breaks present in the producing formation. The length of time that the water bank exists will determine to some extent the size of the tilt to the front, for the vertical flow will be greater with longer flood-out times. The difficult problem seems to be to evaluate the magnitude of this vertical permeability effect to determine if it is great enough to cause a change in water-oil-ratio history. In most reservoirs where shale streaks are plentiful and permeability variations are great, tilt of the flood front is relatively unimportant. Relative time of influence of the tilted front would be small for any overall flood time, and the major effect would be in the higher permeability zones or relatively early in the life of a water flood.

The exception to this would be in a reservoir of a very thick producing zone of very high permeability and no shale streaks. A pattern water flood of an unconsolidated sand formation of approximately two darcys average permeability and 50 to 100 ft thick would be a condition of exception.

From a typical permeability distribution curve, consider the water front in the higher permeability zones. These zones will flood out first. After water breakthrough, these higher permeability zones will produce mostly water. Ultimate recovery of these zones will be, in general, the same for tilted or non-tilted fronts. In a linear system the fact that the flood front was not vertical at the time water entered the producing well makes little difference, since the effect is felt only while the tilted front is entering the producing well. Effect of gravity on ultimate oil recovery in a water flood is much more important when the entire area of the pattern is considered. Effect of a tilted front in a five-spot may have many times the effect as in a linear system of similar characteristics.

Each water flood must be examined individually for vertical permeability and shale barriers before a definite opinion can be expressed on the gravity effects.

Future Reservoirs of Higher-Viscosity Oil

At the present time most water floods are being conducted in reservoirs where viscosity of the oil is quite favorable for high oil recoveries. These floods are being completed, and more and more of the high-viscosity, low-gravity oil zones are being examined for future floods. High-viscosity oil and correspondingly long flood-out times make these reservoirs unattractive for water floods. Add to this the possibility of restrictions on pressures or rate of production, and many projects would be impossible.

In high-viscosity oil reservoirs, channeling or bypassing of water through high-permeability zones is increased as the flood progresses. This unfavorable situation is the result of the great difference in viscosity of the oil and the flood water. It has been suggested in the literature that a restriction of oil-production rate would be more un-

INTRODUCING

FOR THE SMALL RIG OR PRODUCTION HOISTS

TYPE "G" WEIGHT INDICATOR

The Type "G" is a scaled down version of the Martin-Decker "E," "D," and "FS" Indicators and includes the Sensater mounted in the National Supply Co. Deadline Anchor. This gives the small rigs, workover or production hoists the finest possible instrumentation.

The National Anchor with Sensater installed

MARTIN DECKER

Write for descriptive literature E-P95

MARTIN-DECKER CORPORATION

3431 Cherry Avenue, Long Beach 7, California

The World's principal manufacturer of Oil Well Drilling Instrumentation

New Visco Well-Treating Formula Penetrates, Loosens, Disperses Deposits in Tanks, Lines, Tubing

Lowered pumping pressure, Tripled production, Dispersed solid paraffin... Among Spectacular Performance Results with Visco 1111

Visco 1111, on the job in oil and gas producing wells, water-injection wells and salt water disposal systems, has amazed even the most optimistic with its performance and economy. Here are a few examples of how it works to penetrate, loosen and disperse deposits of paraffinic-asphaltic compounds, carbonate scale, sodium salt deposits, iron compounds and other materials causing loss of production.

Cuts Pumping Pressure 175 psi

Injection pressure was 325 psi on a water injection well. Foreman believed pressure was due to a tight formation, but agreed to a test of Visco 1111. Pressure is down to 150 psi—and staying there, with one-gallon-per-day dosage of Visco 1111.

7-Well Cleanup Nets 60 bbl. Increase

Sticking pumps, caused by scale build-up, were causing frequent rod-pulling jobs on a 7-well East Texas lease. Visco 1111 cleaned up the pumps and tubing, upped production 60 bbl. per week. Company now using Visco 1111 on all their wells in East Texas.

Stopped Reperforating Need

On another East Texas lease, wells making high salt water with low-gravity oil tended to scale up and require periodic reperforation. Visco 1111 was given a trial on a well making only 3 bbl. oil and 20 bbl. water a day... quickly jumped daily production to 23 bbl. oil and 60 bbl. water. Cost: only $23.50 . . . as against $300 to reperforate.

Solid Foot of Paraffin Gone

A 500 bbl. tank contained 470 bbl. oil and a 12-inch paraffin bottom—so hard that an oil thief would not drop through. 5 gallons of Visco 1111 and 48 hours later the tank went on at 0.5% B.S. & W., *and no bottom at all.*

Easy to Use, Too!

Visco 1111 has excellent blending characteristics under a variety of field conditions, and does not gel when added to water. Your Visco Service Man will be glad to help you determine proper Visco 1111 dosages for best performance and economy on your leases. Ask him about this new well-treating product . . . or write us, today, for detailed product data.

VISCO PRODUCTS COMPANY
Incorporated
A Unit of Nalco Chemical Company
1020 Holcombe Boulevard — Houston 25, Texas

Visco®
. . . Serving the Oil Industry through Practical Applied Science

Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES
Visco CHEMICALS
Visco SERVICES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

favorable in high-viscosity oil reservoirs when considering total oil recovery. At present, this statement does not appear to be justified. There are apparently no special rate effects on ultimate oil recovery to be expected because of the high-viscosity oil.

Migration of Oil

Regardless of the question of effect of rate on recovery, it is a recognized fact that careful control of relative volumes of injected water and produced oil must be maintained at all times. Operators of a water flood must maintain a balanced flood to prevent migration of oil out of the pattern or even across the lease line. Restrictions on injection rates and especially restrictions on oil production rates will probably make it more difficult to prevent distortion of the flood pattern. Along with this, future changes in waterflood proration would make it more difficult to maintain a balanced flood and to prevent migration.

In many water floods, rate of development is not the same for the entire field. One operator may start his flood and hit a peak production at a different time than the peak production on a nearby lease. A curtailment of the early flood at its peak production could very well cause migration of oil to another property, unless careful consideration is given to the method of curtailment.

Additional Considerations

Some references have been made in the literature to certain specific effects of curtailment of waterflood production.

If curtailment amounts to complete shutdown, then the water pressure is reduced to the formation pressure, and gas that was forced into solution is liberated from the oil. This will result in a movement of the oil and a change in oil volume and viscosity. These effects, due to a slight pressure change, do not appear to be important in the total recovery of oil in a water flood. In fact, if these effects were important, then by maintaining water-injection rates but restricting oil production, there would be a tendency toward increased reservoir pressure and improved flood conditions.

The possibility of soluble minerals dissolved in the flood water being transported to another location in the reservoir and being recrystallized might be considered, but this appears to be of little importance in most floods. However, additional sulfate-reducing problems may be introduced in prorated water floods because of the increased time of the flood.

TABLE 1. Pro's and Con's of Waterflood Curtailment

Pro	*Con*
Laboratory experiments	Permeability variations
Theory of waterflooding	Field performance
Wettability	Economics
Cumulative oil production curves	Gravity effects
Flowing waterflood production	Higher viscosity oil
Natural water drives	Migration of oil

DISCUSSION

It is in order to summarize the pros and cons of waterflood curtailment which have been discussed and to evaluate the significance of each contention. (Table 1).

Apparently, the strongest argument for curtailment of waterflooding is the indication that the theory and laboratory experiments when properly interpreted suggest no effect of rate on ultimate recovery. This appears to be true for laboratory data, but the effect of rate on areal sweep efficiency in a field water flood with its extremes of permeability distribution may be responsible for a difference of opinion. If there is a field effect of rate on recovery, this effect of rate is most probably caused by the changes in areal sweep efficiency. At this time there is not enough known about the sweep efficiency to be able to prove a conclusion on that basis either for or against curtailment.

The second most important consideration for curtailment appears to be an evaluation of imbibition and wetting effects. Here again there is a lack of field data and a definite conclusion is not possible. From laboratory tests and available field indications, it appears that some imbibition forces are active and water and oil are displaced, but it is difficult to prove whether the water and oil movement is an advantage or a disadvantage, with respect to ultimate recovery. Magnitude of imbibition rates appears to be relatively small, and the resulting effect of rate on recovery could also be expected to be small. The strong possibility of intermediate wettability of oil fields and the presence of connate water to satisfy much of the strong surface wetting forces suggest that the magnitude of the imbibition effect is also too small to be observed. However, the fact should be emphasized that, regardless of the lack of beneficial effect by rate reduction, when considering imbibition, there has been no indication of a detrimental effect due to rate reduction.

The strongest argument against curtailment of water floods would appear to be attributable to the permeability distribution through the postulated lack of flooding of the lower permeability zones, although the magnitude of the effect is difficult to evaluate. Actual proof of this phenomenon has never been demonstrated, although if it were in effect in some fields this would undoubtedly have some influence on ultimate production by the flood.

The second most important consideration against curtailment appears to be increasing producing water-oil ratios due to gravity segregation. Here each water flood must be examined individually as to vertical permeability and number of shale streaks present before a conclusion can be reached. The obvious problem of oil migration during curtailment presents a strong argument against proration.

CONCLUSIONS

Injection of any fluid into a reservoir constitutes a special problem, and effects of this fluid injection should be examined in each individual case to determine whether curtailment of producing rates could cause detrimental results.

Aside from any asserted conditions of loss or gain from water floods as a result of curtailment, cold statistics of supply and demand dictate the reduction in oil production at the present time, and this condition may continue for some time into the future. It is probable that at least in some areas some form of waterflood curtailment will prove to be necessary.

Several plans for operating under waterflood curtailment have already been published, and these methods of waterflood operation should be studied in order to determine the best overall recovery procedures applicable under curtailment restrictions.

References

1. Anonymous, "Can Floods Be Prorated Without Loss?", *Oil and Gas Journal*, June 17, 1957.
2. Anonymous, "Oklahoma Considers New Water-Flood Regulations," *Petroleum Week*, May 17, 1957, p. 28.
3. Anonymous, "Proration Hurt Floods?", *Oil and Gas Journal*, April 9, 1956, p. 79.
4. Anonymous, "Water Floods Aired at IOCC," *Petroleum Week*, December 6, 1957, p. 14.
5. Calhoun, John C., "A Resume of the Factors Governing Interpretation of Water-Flood Performance," *Producers Monthly*, April 1957.
6. Funk, E. E., "Effects of Production Restrictions on Water-Flood Recovery," *Producers Monthly*, May 1956, p. 20.
7. Jordan, J. K., McCardell, W. M., and Hocott, C. R., *Effect of Rate on Oil Recovery by Water Flooding*, Humble Oil and Refining Company, August 1956 (Rev.), 68 pp.
8. Murphy, B., "Don't Prorate Water Floods," *Oil and Gas Journal*, February 18, 1957.
9. Murphy, B., "Effects of Water Injection and Oil Production," *Producers Monthly*, November 1957, p. 20.
10. Richardson, J. G., and Perkins, F. M., "A Laboratory Investigation of the Effect of Rate on Recovery of Oil by Water Flooding," *Journal of Petroleum Technology*, April 1957, p. 114.

* * *

When Buying Blowout Preventers

Why take *less* than

SHAFFER'S SPACE-SAVING COMPACTNESS?

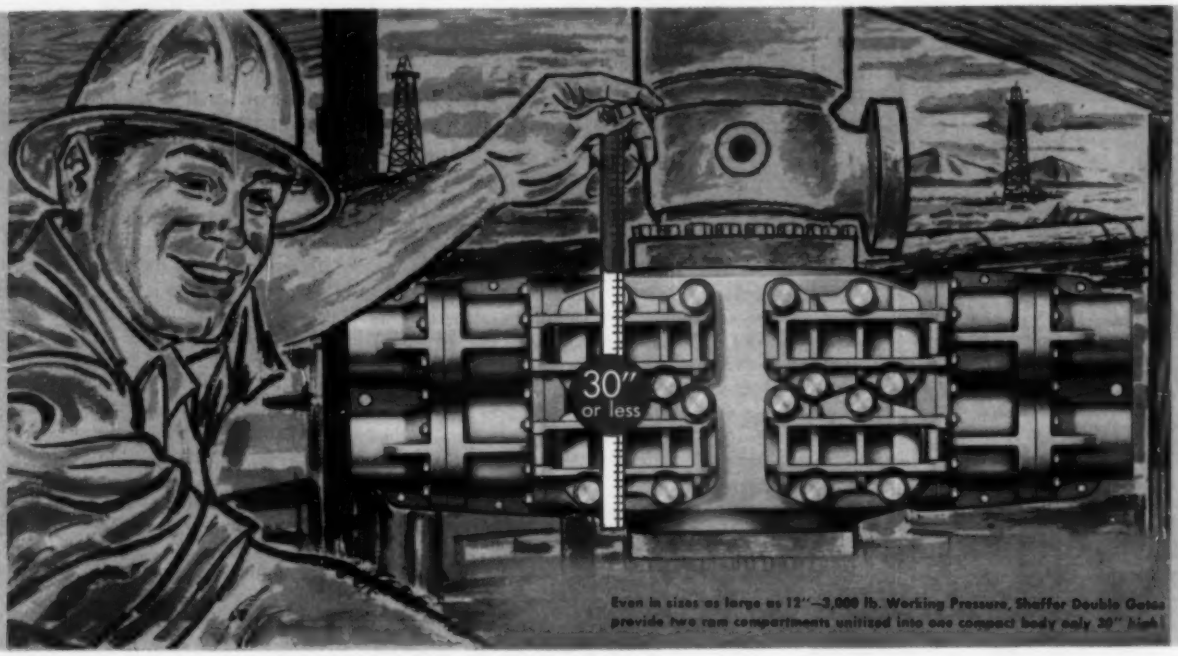
Whether you use cellars—or elevate your rigs—or use a combination of the two—every extra foot of under-rig space wastes money in increased rig-up costs and reduced operating efficiency. That's why it's doubly important to note the multiple ways Shaffer Blowout Preventers save space in your pressure control hook-ups...

1. ***Every Shaffer Gate uses flat rams that combine maximum sealing efficiency with minimum vertical height. Therefore, size for size, Shaffer Preventers are unsurpassed in their space-saving compactness!***

2. ***Shaffer "swing-open" doors for making ram changes further conserve vertical height by eliminating need for extra clearance above each preventer in order to change rams—extra clearance that is necessary where "top-access" ram design is used.***

3. ***Most Shaffer Preventers are available, not only in Single Gate designs, but also in Double Gate designs—two separate ram compartments unitized into one compact, space-saving body that eliminates need for spools and extra connecting flanges.***

RESULT: You make important *multiple* savings in vertical height requirements when you specify Shaffer Blowout Preventers!



Even in sizes as large as 12"—3,000 lb. Working Pressure, Shaffer Double Gates provide two ram compartments unitized into one compact body only 20" high!

SPACE-SAVING COMPACTNESS is just one of many important advantages engineered into ALL FOUR types of Shaffer Blowout Preventers...

TYPE B for general drilling where the compactness of *non-rising* locking shafts is preferred!

TYPE E for general drilling where the quick ram indication of *rising* locking shafts is preferred!

TYPE XHP for extra-high-pressure drilling—to 15,000 PSI *Working* Pressure in 7-1/16" Bore Size... to 10,000 PSI *Working* Pressure in 9" and 11" Bore Sizes!

TYPE LWS for portable blowout prevention on quick in-and-out production jobs (weighs only 780 lbs. in 7-1/16" Bore Size)!

Why not get ALL the facts on the multiple advantages built into Shaffer Blowout Preventers? Write direct for helpful data—or see your nearest Shaffer representative!

37 years OF OIL TOOL LEADERSHIP

SHAFFER

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

CALIFORNIA SERVICE SHOPS: Santa Fe Springs, Santa Maria, Ventura, Avenal, Bakersfield and Taft
HOUSTON, TEXAS: 6006 Navigation Blvd. • ODESSA, TEXAS: 1925 West Second Street
OKLAHOMA CITY, OKLAHOMA: Shaffer Tool Works, 8203 South Shields Boulevard
FARMINGTON, NEW MEXICO: Shaffer Tool Works, Post Office Box 1788
CASPER, WYOMING: Shaffer Tool Works, Post Office Box 827
HOUMA, LOUISIANA: Shaffer Tool Works, Post Office Box 548
EXPORT SALES OFFICE: Shaffer Tool Works: 500 Fifth Avenue, New York, N.Y., U.S.A.
IN CANADA: Shaffer Western Hemisphere, Inc., 5823 103A Street, Edmonton, Alberta.

You can always depend upon Continental Sucker Rods

Anywhere in the world

Continental-Emsco, a fully integrated supply company, is able to maintain constant quality control of Continental sucker rods from raw ore to your well.
Close liaison is maintained with the parent company, The Youngstown Sheet and Tube Company, to assure steels of uniform quality, reflecting the latest improvements developed through continuous metallurgical research.
C-E's sucker rod plant operates under rigid quality control standards.
Wholly-owned supply stores and exclusive representatives throughout the world provide Continental-Emsco quality . . regardless of where you're producing.

For maximum performance . . maximum service . . Specify
Continental sucker rods

CONTINENTAL #1

An economical rod with tremendous staying power in noncorrosive wells or where an inhibitor is used . . yield strength range 60-75,000 psi.

CONTINENTAL #5

A carbon steel rod with an amazing performance record, primarily due to vanadium, which gives it a strength equal to many so-called "high tensile" rods . . yield strength range 75-92,000 psi.

CONTINENTAL #8

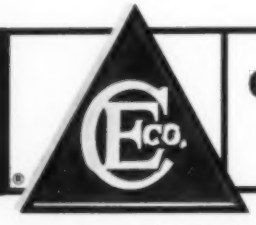
This new Continental #8 rod is priced lower than Continental's premium #10. It offers a moderate degree of corrosion resistance plus top load capacity . . typical yield strength 115,000 psi.

CONTINENTAL #10

The premium quality of this rod results in exceptionally long pumping life in deep, problem and hard pumping wells, where its high ductility and corrosion resistance pay off . . yield strength range 95-110,000 psi.

CONTINENTAL #11

The latest addition to the Continental line. Its low carbon and high nickel content provides high load carrying capacity in corrosive wells . . yield strength range 90-105,000 psi.



CONTINENTAL-EMSCO

Serving the Oil and Gas Industries ... Worldwide

CONTINENTAL EMSCO COMPANY • A Division of The Youngstown Sheet and Tube Company
Export Division, 30 Rockefeller Plaza, New York, N. Y. • Continental-Emsco Company Limited
Continental-Emsco Company C. A., Caracas, Venezuela • Plants: Houston and Garland, Texas; St. Albans, Herts, England •

JMSR 020

Specify CONTINENTAL SUCKER RODS and get C-E customer service . . as important as the steel in the rod

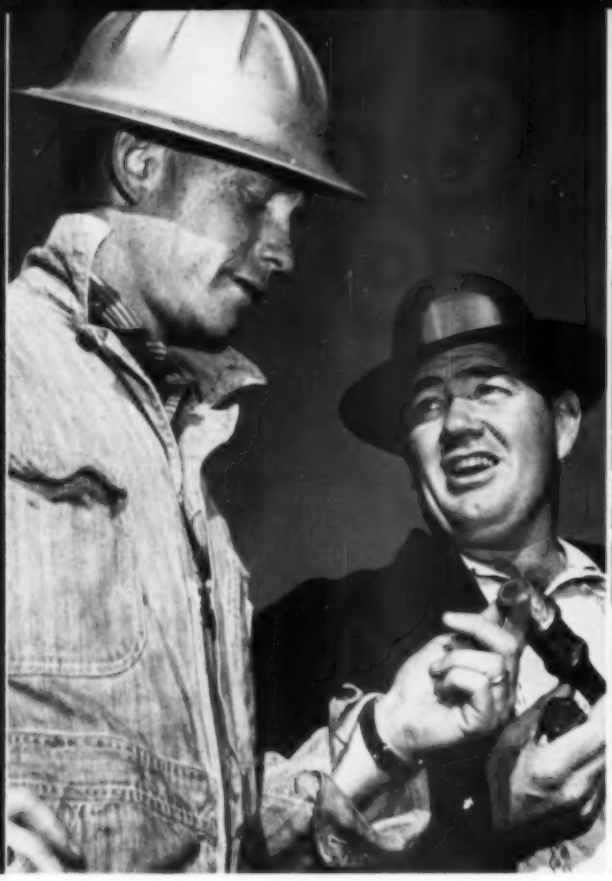
In this day of *tighter profits,* it pays to look beyond the type of steel or grade of rod . . and view the service and facilities behind the sucker rods you buy. *Profit conscious* companies are doing just that . . directing their personnel to specify Continental sucker rods and couplings. And here's why . .

Continental-Emsco *service cuts pulling costs*

. . let a Continental-Emsco Production Specialist have your well fluid or sucker rod failure analyzed. Through Continental-Emsco's metallurgical facilities, he can determine the corrosive content of the fluid . . spot the cause of the rod failure . . and recommend the *right* rod for the longest possible pumping . . *this C-E service costs nothing extra!*

Continental-Emsco *service reduces your engineering costs*

. . plant trained C-E men can engineer an optimum rod string for minimum weight and the lowest possible stress



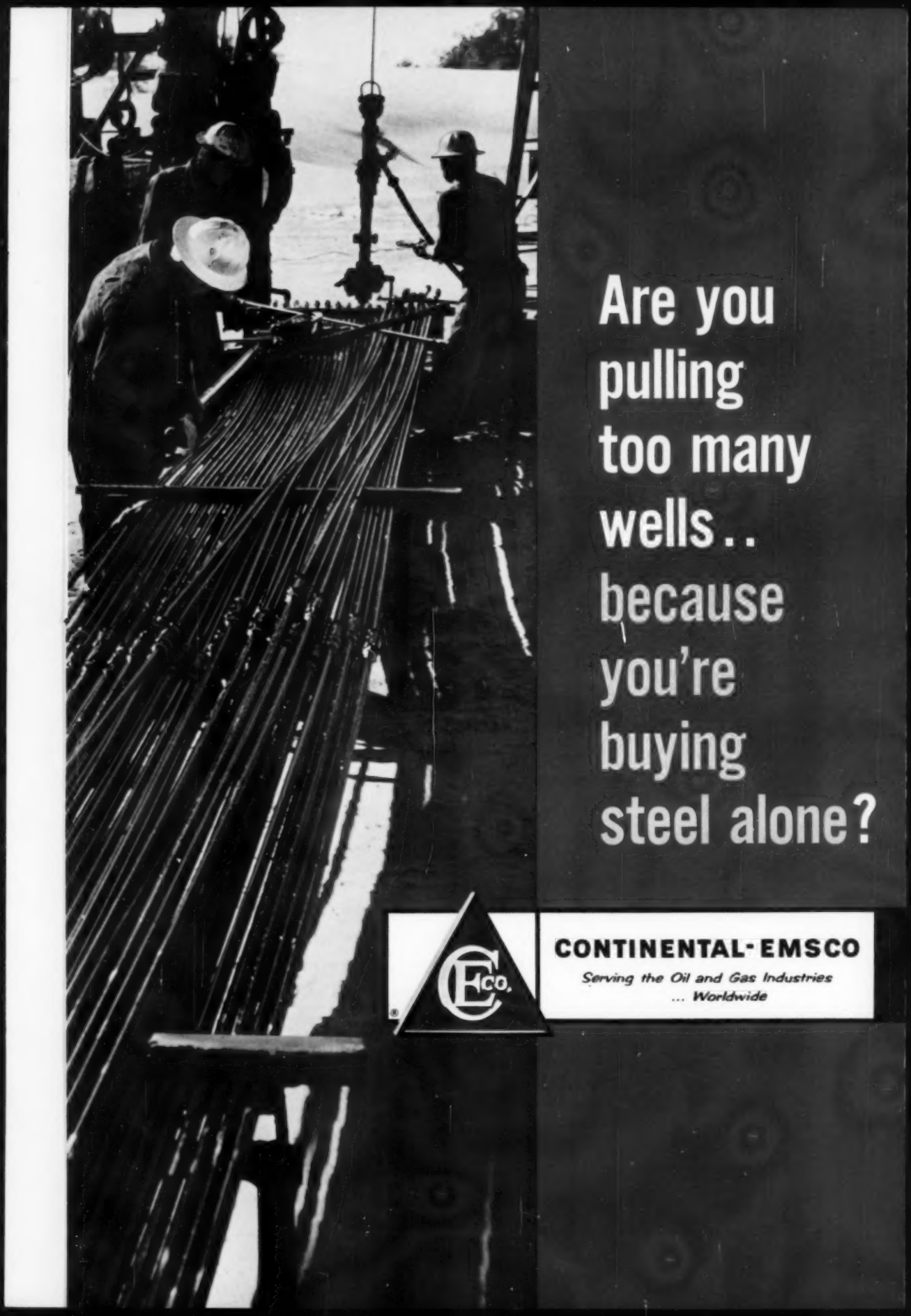
on top rods, unit pumper and prime mover.
This service relieves the work load of your engineering department while providing you with the experience and knowledge of men that are specialists in this field of engineering . . *another C-E service that costs nothing extra!*

Continental-Emsco ***service reduces your operating costs***

. . C-E specialists are fully trained and qualified to make a dynamometer analysis of your wells.
Their recommendations will help eliminate many of the causes of sucker rod failure . . and guide you in proper counterbalancing to (1) cut power costs and (2) reduce wear on equipment. *This C-E service, too, costs nothing extra!*

Continental-Emsco ***service extends equipment life***

. . C-E specialists are always available to train your crews in the right way to handle sucker rods and other subsurface equipment in the field for maximum life . . *additional C-E service that costs nothing extra!*


Are you
pulling
too many
wells..
because
you're
buying
steel alone?
CONTINENTAL-EMSCO
Serving the Oil and Gas Industries
... Worldwide

FEEL IT . . .

SEE IT . . .

SMELL IT . . .

TASTE IT . . .

the SURE WAY to take guesswork out of well completions . . .

. . . is with a Johnston Drill Stem Test. Gives you information on which you can base a decision and be absolutely sure. It removes all doubt, actually puts you in touch with the formation. • Don't chance setting casing on a dry hole — don't pass up a producer.

Test to be certain of your well.

Get the job done faster and better, at less cost.

You get more from a Johnston Test. Call Johnston!

JOHNSTON TESTERS, INC.

P. O. Box 98 Houston 1, Texas

UNION

The *Live Wire Rope Organization

**Charged with creative energy*

To be dubbed "live wire" by customers is nice. But it also is a warning signal which alerts our organization to stay alive to the fact that a greater output of creative energy is necessary when you're in front running position.

In the Union research laboratory and in those of the steel producing organization in which Union is integrated, technicians are hard at work on many new projects. They were started and will be finalized in the field where Union engineers spend more time than in the laboratory.

Classic example of what results from such deep and constant probing is the Tuffy family of wire ropes and slings, each one of them engineered to a specific job.

Among the 1600 standard wire rope constructions, in day to day production, none could be classified as the ultimate low-cost rope on rotary drilling rigs. Many months of experiments in the oil fields convinced Union Wire Rope engineers that rotary rigs called for an entirely new wire rope construction. In the Union laboratory testing equipment unlike any before used was set to simulate rotary rig operation and to impose wear and load factors far beyond those apt to be met in the deepest drilling. Many new wire and strand formulations met destruction before Tuffy Rotary Line was put together.

Thousands of applications on all types of rotary rigs, including the one on the deepest oil well, have established the unchallenged supremacy of—

"Ton-Mile" Engineered Tuffy Rotary Lines

Tuffy Standard Rotary Line is "ton-mile" engineered for standard and for large jackknife rotary rigs. Tuffy Jackknife Rotary Line is for drilling to depths up to 6,000 feet with the smaller jackknife rigs.

Union Wire Ropes For Well Servicing

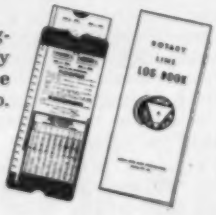
For ultimate low-cost servicing ropes Union rod and tube pulling lines, rod hanger line, sand and pump line, cable tool drilling line and winch line.

At Mount Rushmore National Memorial in South Dakota small fissures in the sculptured faces of Washington, Jefferson, Lincoln and Roosevelt are being sealed with granite dust and white lead. Though the granite sculpture is estimated to last for thousands of years, this preventive maintenance will keep the surfaces smooth and slow the natural erosion process. The insert shows how workmen are suspended on Union Wire Rope.

Worldwide Distribution . . . Not far from wherever you produce or seek oil you'll find Tuffy Rotary Line and standard Union Well Servicing Ropes. You get service on schedule and the ultimate low cost wire ropes at leading oil field supply stores.

Ton Mile Indicator

This slide chart provides you a quick, easy method of figuring ton-miles in following the cut-off practice originally developed by Union engineers. Write Union Wire Rope Corporation, 2106 Manchester Ave., Kansas City 26, Mo.



2-0

Tuffy. Wire Rope Tips

Guard Against These Killers!...Get the Full Measure of Service-Life Built In By Wire Rope Specialists.

Rusty Road to Ruin

Rust—No. 1 enemy of steel—takes a heavy toll in wire rope life. The one-strand break shown here resulted when the rope was allowed to become rust-bound through lack of lubrication. Tests show that properly lubricated rope has up to 10 times the life expectancy of dry rope.

Crushed by a Tractor Cleat

The Sunday punch for this piece of wire rope was delivered by a tractor cleat—just one of many crushing injuries caused by rope being run over or banged into by hard, sharp objects. Even the toughest wire rope is no match for this kind of mistreatment.

After a Suicide Jump

This rope jumped out of sheave and was soon destroyed by pulling around the shaft. Actually it was a case of sudden slack which threw the rope out of the sheave.

Burned on a Frozen Sheave

End of the line came quickly for this rope as the result of operating over a sheave that did not turn. Note the exceptionally heavy abrasion on one side of the rope. Sheaves should be checked thoroughly and often.

Would you like a copy of a booklet in which more than a score of Tuffy Tips like those above are reproduced. If so, write Union Wire Rope Corporation, 2106 Manchester Ave., Kansas City 26, Missouri.

UNION Wire Rope

Subsidiary of ARMCO STEEL CORPORATION

OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company
Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Southwest Steel Products

AOSC Holds Directors Meeting in Dallas

THE MOST IMPORTANT BUSINESS handled at the March 18 and 19 meeting of the AOSC was the presentation of the final draft of the code of ethics. After much discussion the board of directors unanimously approved the adoption of this new code of ethics and made its acceptance required for all AOSC membership. The following is an exact quote of the code as it was accepted and passed on by the board of directors.

"As a condition of membership in the Association of Oilwell Servicing Contractors, I, (name), (title) of, (name of firm), do solemnly swear, by that which I hold most sacred, that I and the firm which I represent, will be loyal to the Oil Well Servicing Industry and fair and honest with those whom I do business; that I will conduct my business with uprightness and honor; that I will hold myself aloof from wrong, from corruption and from tempting others to violate the confidences placed in them by doing corrupt or wrongful acts; that all with whom I deal shall be dealt with fairly and justly; that I shall neither offer nor accept briberies, gratuities or favors of monetary value to gain an unfair advantage, or in lieu of services rendered or materials furnished by the firm which I represent, which directly or indirectly results in deviation or modification of my quoted or published price schedules and/or contracts; that I, under no circumstances or conditions will wantonly or wilfully falsify my records or make charges to my customers for services not rendered or materials not furnished; that I will make available to my customers and to a duly authorized representative of the Association of Oilwell Servicing Contractors the pertinent records of my firm which I represent so that at any time it can be determined conclusively whether I have violated this oath.

These things do I swear,

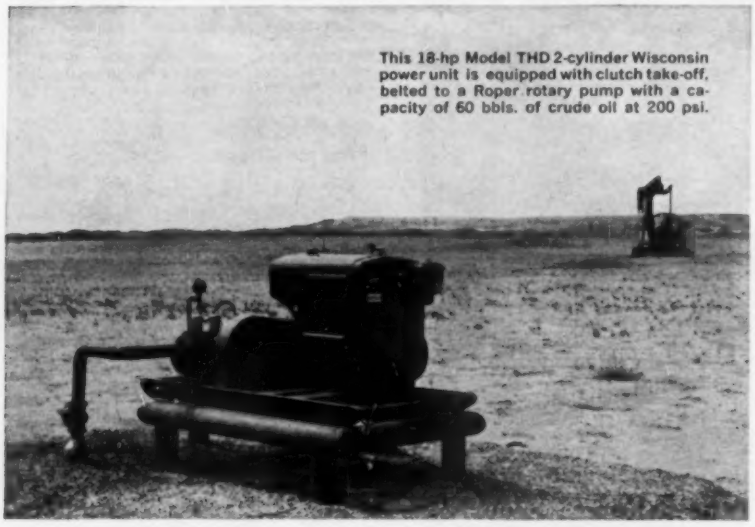
Signed .....

Witnessed by....."

The association has long felt a need for a code of ethics to guide and strengthen its members in fair dealing with its customers and to set an example for all well servicing contractors to desire to achieve. It guarantees to its customers fair business practices and is an assurance that full value in well servicing work will be received for each dollar paid to a member of the AOSC for well servicing work.

The board was formally introduced to Aaron D. Baker, who is the new assistant executive secretary. Mr. Baker spoke briefly about his activities since joining the AOSC several months ago. He also discussed a new first aid and fire extinguisher kit that exceeds minimum requirements and is supplied to AOSC members at a cost much less than it could be purchased commercially. This is because Mr. Baker designed the unit and purchases all materials directly. AOSC members pay only for the actual cost of the materials.

Jim Danheim, executive secretary, presented the applications of 40 oil well servicing firms for membership. This encouraging growth rate is the result of much activity directed toward obtaining new members since the time of the annual meeting last January. President Jimmy W. Wilkins of Andrews, Texas, presided at the meeting and there were many committee reports presented during this two-day board meeting. Among the committees reporting were the executive, convention, financial, nominating, business methods, cost analysis and accounting. Also the committees for association mutual insurance problems, safety, budget and operating, code of ethics, honorary advisory, membership-public relations, legislative, and the allied group advisory committee. ★ ★ ★



This 18-hp Model THD 2-cylinder Wisconsin power unit is equipped with clutch take-off, belted to a Roper rotary pump with a capacity of 60 bbls. of crude oil at 200 psi.

Here's **ENGINE POWER**
tailored for your isolated installation

Operating in the "Four Corners" area of northwestern New Mexico, this Wisconsin-powered pipeline unit was selected by a major crude oil purchaser because of previous experience in Southwest Texas, Wyoming, and Canada. They were *pre-sold* on the self-sustaining dependability of Wisconsin Engine Power, working under rugged conditions in hot, remote regions.

The Wisconsin Heavy-Duty Air-Cooled Engines are "tailor-made" for this type of operation. Dual carburetion enables the engine either to operate on gasoline or to run "off the land," using natural gas. Stellite exhaust valves and valve-seat inserts and positive rotators increase valve life 200% to 500%.

Exceptionally efficient AIR-COOLING at all temperatures from low sub-zero to 140° F. licks the cooling problem anywhere, at any season. Heavy-duty design and construction in all details is your unwritten guarantee of long engine life and low-cost maintenance. Basic high torque provides the load-lugging power that keeps the engine rolling regardless of load variations.

You can't do better than to specify "Wisconsin Power" for your oil field utility units. Write for engine bulletin S-249. J-154

WISCONSIN MOTOR CORPORATION
Milwaukee 46, Wisconsin

WRITE TO HARLEY SALES CO.
910 SOUTH MAIN STREET - TULSA, OKLAHOMA
8480 McKINNEY AVENUE - HOUSTON, TEXAS
606 SOUTH MAIN STREET - WICHITA, KANSAS
Oil Field Distributors for Wisconsin Engines and all types of Utility Units

World's Largest Builders of Heavy-Duty Air-Cooled Engines

CHEMICAL ACTIVATORS FOR GYP REMOVAL CONTROL

REMOVE GYP CHEMICALLY!

Halliburton's *new Gyp Removal Solution* is designed to penetrate normally insoluble gyp scale (calcium sulphate) . . . and convert it into an acid soluble scale which can be removed by conventional acid treatments. This remarkable advance helps eliminate the costly task of pulling tubing to remove scale.

CONTROL GYP CHEMICALLY!

Scalechek is Halliburton's technique of placing SCP materials, scale control polyphosphates, into a producing formation to help provide protection against gyp deposits and other scales for extended periods of time at temperatures up to 260°F. Scalechek materials may be injected in conjunction with a fracturing operation . . . or it may be injected without sand.

These two chemical processes are now in wide use as a part of Halliburton's continuing program of providing the Petroleum Industry with fast, efficient help . . . anytime . . . any place it is needed. Your local Halliburton Representative is your link to this chain of service. Contact him on your next job calling for creative chemistry.

REMOVE GYP CHEMICALLY!

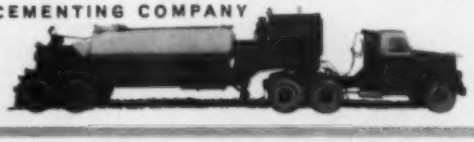
CONTROL GYP CHEMICALLY!

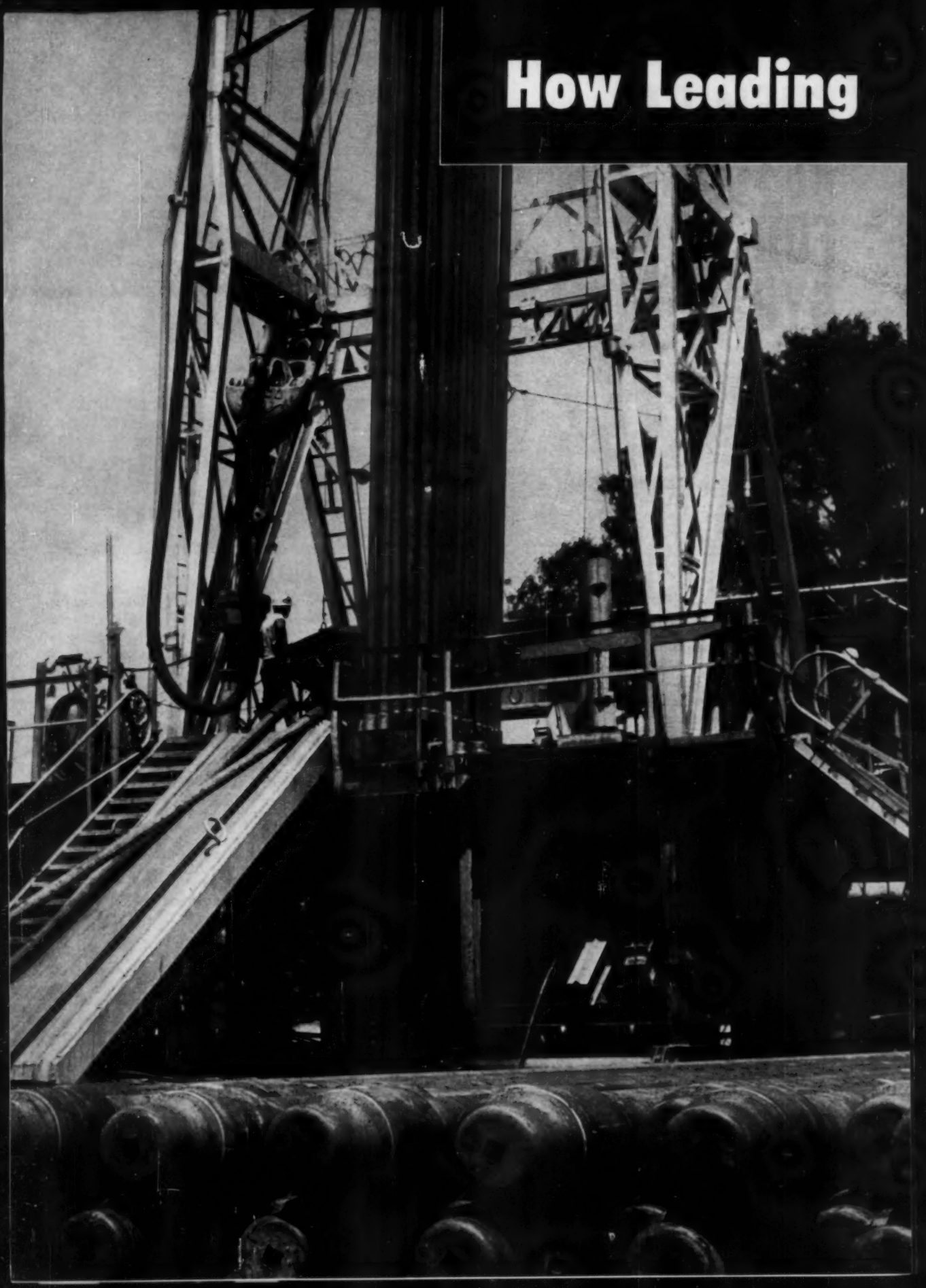
"Continue to Look to Halliburton for Leadership."

HALLIBURTON CHEMICAL SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY

DUNCAN, OKLAHOMA




How Leading

Drilling Contractors Cut Costs

Competition in the contract drilling industry was never keener. Drilling contractors must find new ways to lower their operating costs if they are to show a profit.

It is significant that many of the leading drilling contractors depend on equipment sold and serviced by Jones & Laughlin Supply Division. These leaders discovered long ago that lower first cost did not always mean lower final cost. They know they must use equipment that will give them more performance hours per dollar invested. This is why you'll find quality drilling equipment sold by Jones & Laughlin on the job for these industry leaders.

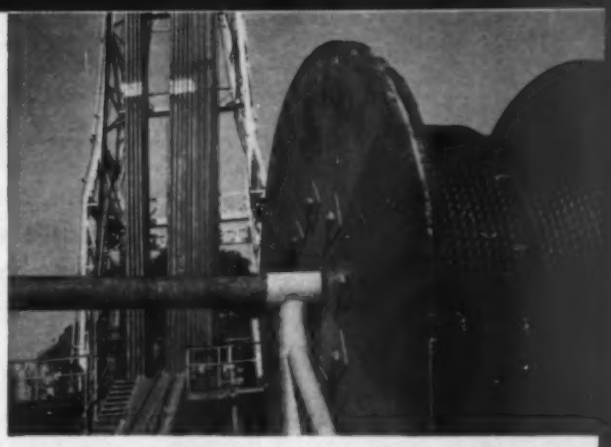
Backed by J&L service with field stocks of expendable supplies and replacement parts, these drilling contractors have cut their costs consistently.

Quality equipment and dependable service can lower *your* operating costs, give you the edge on competition. See your local J&L man today.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

If it's sold by J&L....
It's the best available 101



Because of unusual quality in materials and construction, J&L Wire Rope gives more ton miles. Result: Lower operating costs per foot of hole.

Three Gardner-Denver Mud Pumps on a well in Mis sippi. Replacement of all Gardner-Denver parts can be made in the field, and these parts are as near as your J&L Supply store.

No tools needed to lay your temporary galvanized steel lines with McDowell "Fast-Line" Couplings. You save up to 80% installation time. Ask for illustrated booklet.

J&L's quality Blue Ribbon Drill Pipe is preferred by the drillers of the world's deepest wells. The J&L quality control program is the most exacting known. Ask your J&L Supply man for a beautifully illustrated 24-page booklet on oil country tubular goods.

MODERN WELL COMPLETION SERIES

PART 6

How To Design And Run Casing Strings

Well depth, competency of strata, and reservoir pressure of porous strata must be considered in using casing to shut off troublesome horizons, protect investment in the hole, and to control and produce the completed well.

J. F. Hendrickson, *Phillips Petroleum Company, Houston, Texas*

IT IS THE OBJECTIVE of this presentation to discuss some of the many factors that enter into the design and running of casing strings and to present a few illustrations showing how they apply in different localities and circumstances.

There is the need for careful investigation and consideration of all factors when designing or attempting to improve on standard designs of casing strings or supervising the running of casing.

Uses of Casing

Simply stated, casing is used in drilling a well to shut off horizons that will prove troublesome in drilling deeper; protect the investment in the hole that is drilled; and enable the control and production of the completed well.

This is accomplished through the use of two or more casing strings named in Fig. 1. The functions of each string are briefly described in Appendix 2. Well depth, competency of strata drilled, and reservoir pressure of porous strata are the influencing factors in determining the number of casing strings required.[1]

Types and Functions

Conductor. This short string of pipe is always required in water locations and in localities having incompetent formations, such as the Gulf Coast. As can be seen from its tabulated functions it would not be required in a locality where competent rocks are at, or immediately under, the surface.

Surface. All wells require surface pipe whether or not a conductor string is set. Its greatest functions are to protect fresh water sands and to provide a foundation and support for wellhead equipment, subsequent casing strings, and to prevent loss of circulation.

Protector string. One or more protector strings may be required to enable continued progress in drilling. Needs for a protector string are greatest in drilling deep wells, in areas of high pressure, incompetent strata, and zones of highly corrosive waters.

For instance, along the Gulf Coast it is not uncommon for incompetent strata that will only support a column of 12.5 lb per gal or less mud to be immediately above a competent strata that will require a mud weight of 14.5 lb per gal or more to overbalance the salt water or hydrocarbon contents. If a protector string is not set before penetrating the stratum containing fluids under high pressure, these fluids will produce into the well bore, causing the mud column to kick, or back flow.

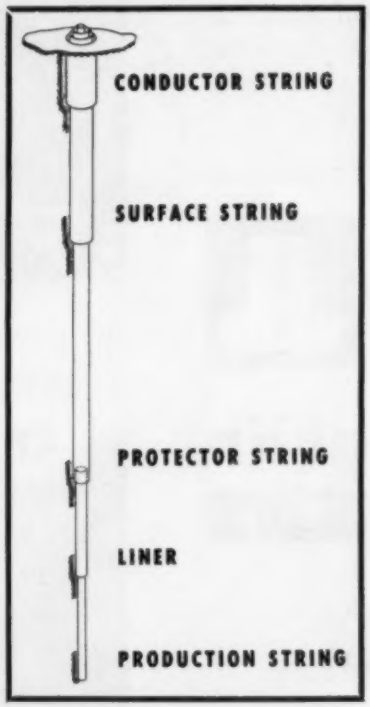


FIG. 1. Casing strings telescope to depths of well. Conductor string retains incompetent formations, surface pipe protects fresh water sands. It provides a foundation and support for wellhead equipment, subsequent casing strings, and prevents loss of circulation. Protector string allows progress in drilling, production string protects pay horizons encountered, and using a liner reduces cost.

When blowout preventers are closed, pressure builds up causing the incompetent formations to break down, placing the higher pressure and lower pressure strata in communication. Drill strings stick, causing expensive fishing jobs and possible loss of the hole.

On the other hand, in the West Texas area, long sections of hole may be drilled through competent limestone or sand strata without encountering high pressure reservoir fluids. Consequently, there is less frequent need for protector strings.

Production string. The other casing strings are used primarily to reach the projected depth of the well, whereas the production string primarily protects the productive horizons encountered, the investment in the hole; and permits an orderly completion, production, and recompletion program throughout the economic life of the well.

Liner. A liner may be run in place of a protector or production string. The liner can be set at the same point as the string it replaces. However, instead of extending to the surface, its top is approximately 100 ft up into the next larger size casing.

The advantage of using the liner is reduced cost. However, it provides protection to only the portion of hole that it occupies. Protection in the top part of the hole is provided by the larger size of casing.

Small sample of the rigsite inventory you'd need if National Supply Stores weren't so convenient!

THE NATIONAL SUPPLY COMPANY
NSCO

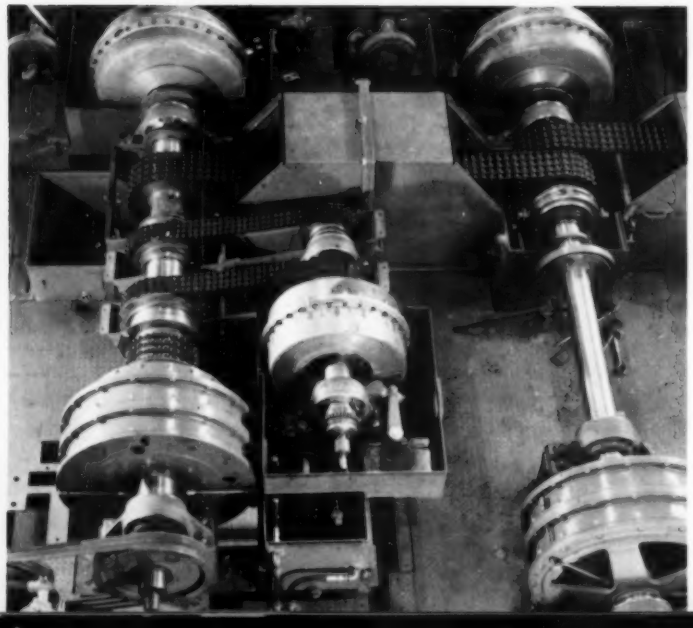
Imagine how your "backyard" would look if you had to maintain your own inventories. Imagine the time you would spend buying the thousands of items you might logically use. Imagine the manpower costs of maintaining stocks and keeping inventory records.

Your nearby National Supply Store takes care of all these details for you. There are actually over 65,000 different items stocked in our 120 stores. Every item is either manufactured by National under the strictest quality controls, or purchased from the leading manufacturer in any specific field. Typical of the recognized product lines you'll find in National stores are Ajax engines, Stockham fittings, Oilmaster pumps, Westinghouse motors, as well as those shown above.

Next time you buy supplies, prove to yourself that National Supply stores are your most convenient source for complete stocks of quality brands.

On next pages: Two National drawworks components to lower drilling costs

NATIONAL AUXILIARY



This National Auxiliary Drawworks Drive, installed on a National 80-B rig, gives the operator full pump power and control of rotary speeds.

Exclusive field-tested drive system permits all engines in a drive group to operate as a single pump power unit while drilling. Power is diverted to operate the rotary via the drawworks under the very accurate control of a fluid coupling. No single engine can be light loaded or severely overloaded—a condition which frequently occurs without this drive.

DRAWWORKS DRIVE

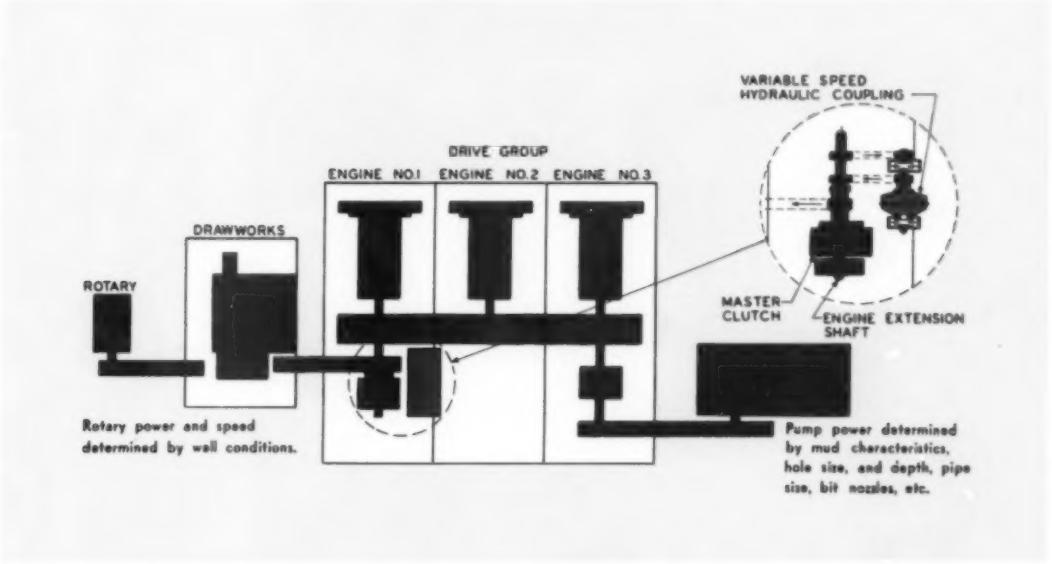
delivers maximum pump power plus complete control of rotary speeds

Drilling is faster and cheaper when you install a National Auxiliary Drawworks Drive on your rig. You can give the pumps *all available rig power* and distribute it as conditions require. And at the same time, you can drive the rotary at the *exact* speed that hole conditions require.

Here's how you benefit with this exclusive drive group arrangement: 1. Complete control of rotary table speed over the entire range from the fastest to the very slowest. 2. Fine control of drawworks input power for any operation. 3. Maximum power for pumps from *all* engines.

National has an Auxiliary Drawworks Drive for any rig, regardless of age, size, make or model. For a National rig, we offer the integral design as shown in the schematic drawing below. For other rigs, we supply the Independent Model, which is set between the drawworks and the drive group. Both provide a controlled "soft" drive to the rotary.

Ask your nearby National Supply representative to show you how these National Auxiliary Drawworks Drives deliver full pump power . . . plus complete control of rotary speeds.



This schematic drawing illustrates makeup of the National Auxiliary Drawworks Drive, consisting of a small fluid coupling, scoop controlled, mounted on a countershaft on the front engine frame. Power is transmitted to this fluid coupling by means of a chain drive from the front drive group shaft. Output from fluid coupling is transmitted by chain to the drawworks drive quill sprocket on the No. 1 engine extension shaft.

The compact #6 Micromatic unit is located directly in front of the drawworks, adjacent to the brake handle. The controls for it are directly above the driller's console. Controls can be engaged or disengaged without waste motions. After driller determines the desired amount of weight on the bit, micromatic control takes over the drilling operation and maintains this correct weight.

NATIONAL MICROMATIC DRILLING CONTROL

Automatic control speeds drilling, increases safety factor

Micromatic control brings to drilling the precise performance of your most skilled driller, without the human elements of fatigue or diverted attention.

Essentially, micromatic control is an automatic driller, operating the drawworks brake and controlling penetration rate. Feeding is smooth and continuous with the drilling string under complete control at all times.

Safety is inherent in this control. Its feeding function is operative only when the clutch for driving the rotary machine is engaged. All parts are interdependent, so failure of any component can only result in automatic restraint of feeding.

Compact micromatic controls for both straight and directional drilling are adaptable to any rig. Installation time is fast and can be done on location. See your nearby National Supply representative for complete information.

THE NATIONAL SUPPLY COMPANY

Two Gateway Center, Pittsburgh 22, Pennsylvania

Subsidiary of Armco Steel Corporation

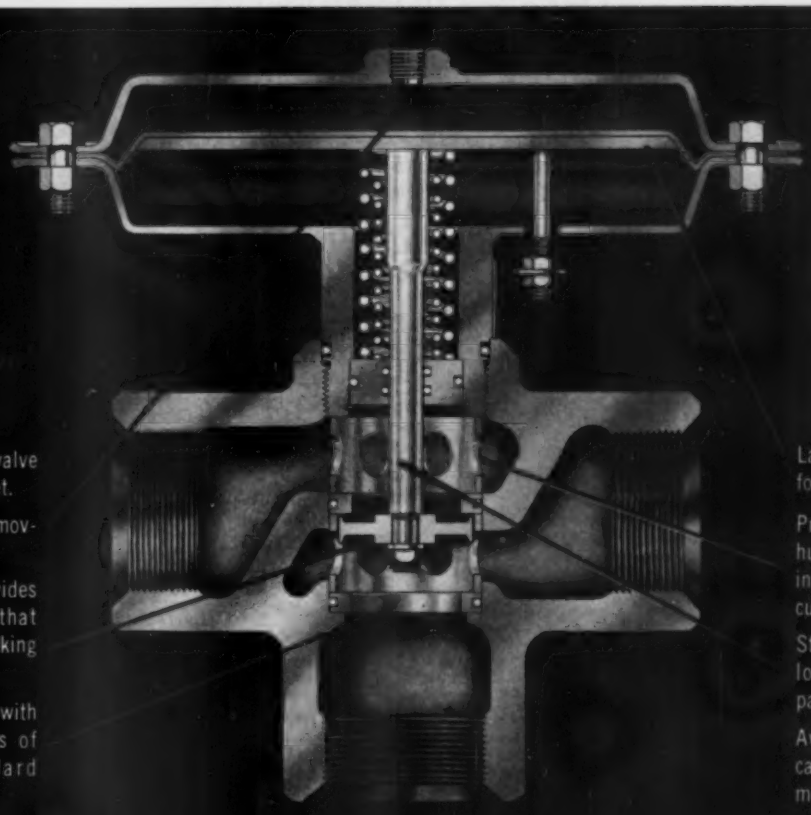
DIVISION OFFICES: Calgary, Columbus, Dallas, Denver, Houston, Torrance, Tulsa

EXPORT: 600 Fifth Avenue, New York 20, N.Y., U.S.A.; City Wall House, Chiswell Street, London E.C. 1

NEW

GARRETT DIVERTER VALVE

NEW LOW COST
NEW LOW MAINTENANCE
NEW OPERATING FLEXIBILITY



Lowest cost of any valve of this type on market.

All inner parts are removable from top.

Bonded soft seat provides bubble tight seal that holds under all working conditions.

Large flow capacity with 1.77 square inches of opening in standard 2-inch valve.

Large 8-inch diaphragm for low pressure operation.

Pressure drop occurs in huddling chamber protecting seat and disk from cutting action.

Stainless steel trim gives longer life to exposed parts.

Available in shop fabricated and tested skid-mounted headers.

The new Garrett TPOR-1 Diverter Valve is an economical three-way two-position valve for low pressure automatic well testing systems and other applications where it is necessary to divert flow. Engineered for dependability and long life, the TPOR-1 Diverter Valve offers maximum flexibility of application.

Consult your nearby Garrett sales and service office for an economical solution to your control valve requirements . . . or write direct.

USI **Garrett Oil Tools**

Division of U. S. Industries, Inc. P. O. Box 2427, Longview, Texas

For instance, if the larger size of casing will provide the protection needed from any surface pressures or corrosive waters that may be encountered, then a liner may serve in place of a full string of pipe.

Forces Considered

There are four forces that should be considered in casing design. These are buckling, tensile, external pressure and internal pressure imposed by conditions named in Appendix 2. The theoretical approach to design against these forces is extensively covered in various publications.[2] This presentation will briefly enumerate factors that impose the forces and state illustrated applications for design purposes.

Buckling. Design against this force need be done only in instances of wells drilled in water and incompetent surface beds such as marshes. Also, the design against this force is applicable only to the conductor and surface strings.

Provisions for other forces in other strings generally provide resistance to any buckling forces encountered except in areas of land shifting (fault planes), where it may be possible to make special provisions.

Tensile. This force is applied to all strings except the conductor string. The greatest stress is imposed in the upper portion of each string or the upper portion of each section if tapered strings are run. The calculations generally made are simple and straightforward, being based primarily on load per unit of cross sectional area for the grade of steel used.[3,4]

External pressure (collapse). As in the case of the tensile force, design must provide for external pressure on all strings except the conductor string. Maximum external pressure, however, is exerted at the bottom of each string or the bottom of each of the lower sections in the case of tapered strings.

The differential weight of the fluid column and formation pressure is the only force normally considered in design. The calculations are based upon the maximum weight of the column of the fluid on the outside of the pipe minus the weight of the column of fluid on the inside of the pipe under certain assumed minimum conditions.

Internal pressure (burst). The need to consider this force is most prevalent in the Gulf Coast, where relatively high wellhead pressures are encountered. Generally, in other areas, pipe of sufficient physical properties to withstand the tensile and collapse forces will be adequate to withstand the burst forces that may be imposed.

This is not true in areas such as the Gulf Coast, where pressures ranging from 0.6 to 1.0 lb per ft of depth are encountered. Failure to recognize and design for this situation may result in costly well-repair work in the event of an impending blowout, casing or tubing burst-type failure.

J. F. Hendrickson *is assistant production superintendent of the Gulf Coast division for Phillips Petroleum Company.*

He joined Phillips soon after graduation from Oklahoma State University in 1934 with a degree in mechanical engineering. He served as staff engineer in Seminole, Oklahoma, Borger, Texas, and Bartlesville, Oklahoma.

In 1940 he was promoted to assistant district superintendent at Borger, Texas. After serving in the Northeastern Oklahoma and Eastern Kansas areas as an assistant superintendent, he was made assistant chief production engineer in 1948. He assumed his present position in 1952.

Hendrickson is a member of SPE of AIME and is registered in Texas as a professional engineer. He is active in API Southern District activities and committee work.

Design Factors

The API Bulletin 5C2[5] on performance properties of casing and tubing, and manufacturers' published engineering data books[4] provide formulae and data on which to base design calculations. A number of variations in available types of API casing permit accomplishing practically any desired design.

Various qualities of steel, consisting of API Grades F-25, H-40, J-55, N-80, and P-110; various weights per foot (wall thicknesses); and different lengths of couplings are all available.

These permit arriving at a suitable design for any given string. This is illustrated in the accompanying tabulation of some data available on part of the weights of one size (5½ in. OD) of casing.

Variations in Types of API Casing.

Grade	Weight lb per ft	Collapse Resistance psi	Internal Yield Pressure psi	Joint Strength 1000 lb
F-25	13.00 only	1660	1810	95 ST&C
H-40	14.00 only	2440	3110	139 ST&C
J-55	14.00 Lightest	3170	4270	186 ST&C
	17.00 Heaviest	4500	5320	234 ST&C
				275 LT&C
N-80	17.00 Lightest	5890	7740	320 LT&C
	23.00 Heaviest	8900	10560	440 LT&C
P-110	17.00 Lightest	8520	10640	418 LT&C
	23.00 Heaviest	12870	14520	576 LT&C

Note that a weight and grade of pipe is available which provides a collapse resistance range from 1660 to 12,870 psi and an internal yield pressure rating of from 1810 to 14,520 psi. The maximum strength in each instance is approximately eight times the minimum.

The following conditions must be known or assumed in designing a string of casing:

1. **Hole size — in which casing is to be run and to be drilled through the casing**
2. **Derrick and rig capacity**
3. **Availability and costs of appropriate sizes, weights, and grades**
4. **Setting depth**
5. **Maximum reservoir pressure or mud weight**
6. **Desired design (safety) factors**

The first two items are given attention in the design of new programs, deep wells or unusual hole circumstances. The last four items must receive consideration in the design of any string.

There is no standard design factor for any force that is generally accepted in all areas, in a given locality, or even without exception within a company. This is illustrated by the following brief summary from a report by the API Mid-Continent District study committee on casing string design factors.[5]

External pressure-collapse	
Design factors used	1.00 to 1.25
Assumed conditions:	
mud weight	9.625 lb/gal to actual
pipe empty	Generally-yes
Tension	
Design factors used	1.50 to 2.00
Buoyancy considered	Generally-no
Internal pressure-burst	
Design factors used	1.00 to 2.00
Reservoir pressure considered	Generally-yes
External gradient considered	About 50% consider, using actual or 0.5 lb/ft

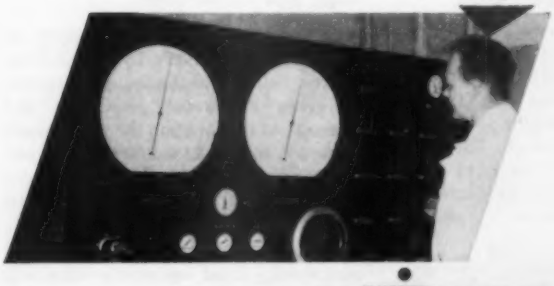
The fact that there is no given standard design factor in use is understandable, because conditions are not the same in all localities; companies operating in the same area take calculated risks of different degrees; and conditions vary throughout the operating territory of one relatively large company.

This is where the engineer's experience and forward-looking manage-

RESULTS START HERE!

What are the things you expect everytime you specify *Halliburton* for your fracturing operation? An experienced crew working with the most modern fracturing equipment ... the latest fracturing materials ... the *best* from a wide selection of fracturing techniques to help obtain a successful job. You may be familiar with these ... but what about the wealth of experience, facilities and activity of the research men who make up the Halliburton team behind the fracturing crew? These advantages are yours, too ... when you specify Halliburton:

CHEMICAL R & D LABORATORIES ... the most complete of any oil field service company in the world. Here, skilled research chemists and engineers seek answers to problems such as – "The best cementing practice for improving formation fracturing" ... "The most applicable fluids for a formation." A constant research program is maintained for developing new and improved fracturing fluids, additives and techniques. They also search out information for you by making chemical and physical analysis of cores and cuttings ... utilizing X-ray diffraction and other techniques.



M R D (Mechanical Research and Development) ... Here, millions of dollars and thousands of man hours are invested in improving current fracturing equipment ... and developing completely new ideas to do a job better -- faster -- more economically than ever before.

EQUIPMENT DESIGN / TOOL DESIGN ... Here, complex equipment is engineered to meet specific field requirements. One section is constantly improving fracturing equipment efficiency and developing new equipment ideas. The other section designs special tools and other down-hole equipment to help obtain more successful fracturing jobs.

DATA PROCESSING ... This newest member of the fracturing team helps speed data precalculations ... charts information ... performs a multitude of tasks with lightning speed to determine the best engineering combinations for optimum fracturing conditions and results. The rows of processing equipment and giant electronic memory units used here are the largest, most useful facilities of this type ever to be employed by an oilfield service company.

BE SURE YOU GET THESE PREMIUM BENEFITS ON YOUR NEXT FRACTURING JOB! ALWAYS CALL HALLIBURTON!

Visual and permanent records of your fracturing operation on-the-spot ... the HALLIBURTON FRACOMETER! Ask about it.

HALLIBURTON
FRACTURING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY • DUNCAN, OKLAHOMA

FIRST ... AND STILL FOREMOST ... IN FORMATION FRACTURING

ment can effect economies in the highly competitive business of drilling for and producing oil and gas.

Economics

Under "Uses of Casing," it was pointed out that casing was required to enable progress in drilling, to protect the investment in the hole and to control and produce the completed well; thus, the most economical drilling program, casing program, and the most economical design of each individual string of casing that will satisfy the requirements for casing is the best design from an economic standpoint.

This does not mean that the design that costs the least amount of money is necessarily the most economical design.

To illustrate, Appendix 3 was prepared showing three different designs for a 15,000 ft 5½ in. OD casing string. Each of the designs meet the minimum design factors selected for tension and collapse. The cost of Design 1 is $40,000, Design 2 is $60,000, and Design 3 is $70,000.

A few years ago the less costly Design 1 was used on several wells having a shut-in tubing pressure of 8300 psi, until trouble developed from tubing rupturing, thus causing expensive workover jobs.

The problem with the tubing could not be immediately solved and so casing of Design 3 was run, which cost $30,000 more. Under the circumstances, this was considered the most economical design because Design 3 had an internal pressure rating at minimum yield of 14,500 psi as compared to 10,560 psi for the heaviest section of Design 1. Thus the increased cost of $30,000 would permit containing the well in the casing if necessary rather than taking the calculated risk of having the well blow out of control at a cost far greater than $30,000.

With the drilling of additional wells, however, and some improvement in tubing quality, the risk was reduced and a compromise, Design 2, was adopted at a reduced cost of $10,000 over Design 3 but still at a cost of $20,000 more than the minimum design.

The illustration shows the importance of the factor of economics when considering casing string design. Further evidence of the importance of carefully considering economics in designing casing programs is the fact that casing costs alone amount to about one third of the total cost of a 15,000 ft high pressure Gulf Coast well.

Running Casing

A brief reference will be made to the broad aspects of running casing such as preliminary planning; the different phases in preparation for actual running; and the different phases of the job upon which the engineer should educate himself and be prepared to educate others. Brief mention will be made of some general metallurgical considerations that affect performance of the string.

Pre-job planning. Depending upon the size of the organization, there are a number of supervisors and personnel who have direct responsibilities concerning design and procurement of the pipe, and related equipment. They also procure handling equipment and supervise the mechanics of rig up, conditioning the hole and of running the casing.

Because of the split responsibility concerning the different phases of the overall job, it is important to delineate the responsibility between the different supervisors or people involved, such as the material man, foreman, toolpusher and engineer. This is especially true of the long, expensive, tapered casing strings used in deep wells.

A part of the delineation of responsibility should be adequate education in proper handling and in having proper respect for the pipe being used. To tell a man that he is responsible for doing a certain thing is not enough. The man must possess enough of the right kind of knowledge to be able to satisfactorily discharge the responsibility placed upon him.

The use of higher alloys, N-80 and P-110 API grades and special materials each stressed to a higher level than was done in years past when drilling shallower, lower-pressure wells, has made it imperative that the pipe be handled with tender care and that it be properly respected.[6,7]

Serious damage often occurs during the unloading of casing from the trucks to the racks, both at the pipe yard and at the location. This damage in the form of dents, mashes and bending substantially reduces the effectiveness of the pipe. For instance, a tube deformed one percent out of round is reduced in resistance to collapse by approximately 25 percent. A substantial blow with a sharp object will lead to failure, particularly in the notch-sensitive higher alloy materials or through stress corrosion cracking in a corrosive environment.

Welding of the casing, particularly the N-80 grades and higher should be avoided and if performed, special precautions followed. Recently-developed plastic thread locking materials enable dispensing with certain welding previously done on critical connections.

Because of the notch sensitivity of the high alloy materials, the dies and types of slips in tongs, spiders and elevators should be selected which will perform the intended function with a minimum of notching of the tubing.

The education and placement of responsibility for proper handling is desirable and in many cases necessary to accomplish the initial objective in the drilling of the well and to protect the investment in the pipe and the hole. An engineer can be of great service in educating himself and in turn educating others in the proper procedures and techniques to follow in all phases of the operations that utilize tubular goods.

There are a number of preliminaries that must be taken care of between pre-job planning and the actual start of running operations. The hole must be logged and conditioned and the pipe prepared for running.

Equipment needed for and related to the job must be assembled. This includes floating equipment, scrapers, scratchers, blowout preventer rams, and pipe handling equipment such as tongs, slips and elevators.

Preparation of pipe. The pipe to be used, prior to delivery to the location or after delivery to the location, should be given a careful inspection and cleaned. At the location the pipe should be sorted into grades and weights and into the proper order for running. All lengths of the size to be run should be numbered and tallied.

A commercial inspection service is customarily used on strings that will be in critical service. Regardless of this, however, each length should receive a careful visual inspection for evidences of mechanical damage to the threads or the body. The threads should be cleaned, conditioned and protected to a high degree. This is of the utmost importance if full pressure-tight benefit of the string is to be realized.

Special care must also be given to see that the pipe is placed and run in the proper order, because a misplaced length of lightweight or low grade casing could result in a very expensive failure.

Pre-running conference. Immediately prior to the start of actual running operations, it is most helpful to have a conference of all directly-responsible supervisors for assignment and review of their duties on the job and to issue or review running instructions. Experience has shown that too much emphasis cannot be placed on issuing proper instructions concerning the handling, stabbing, spinning rate, torque, lowering rate and frequency of fill up.

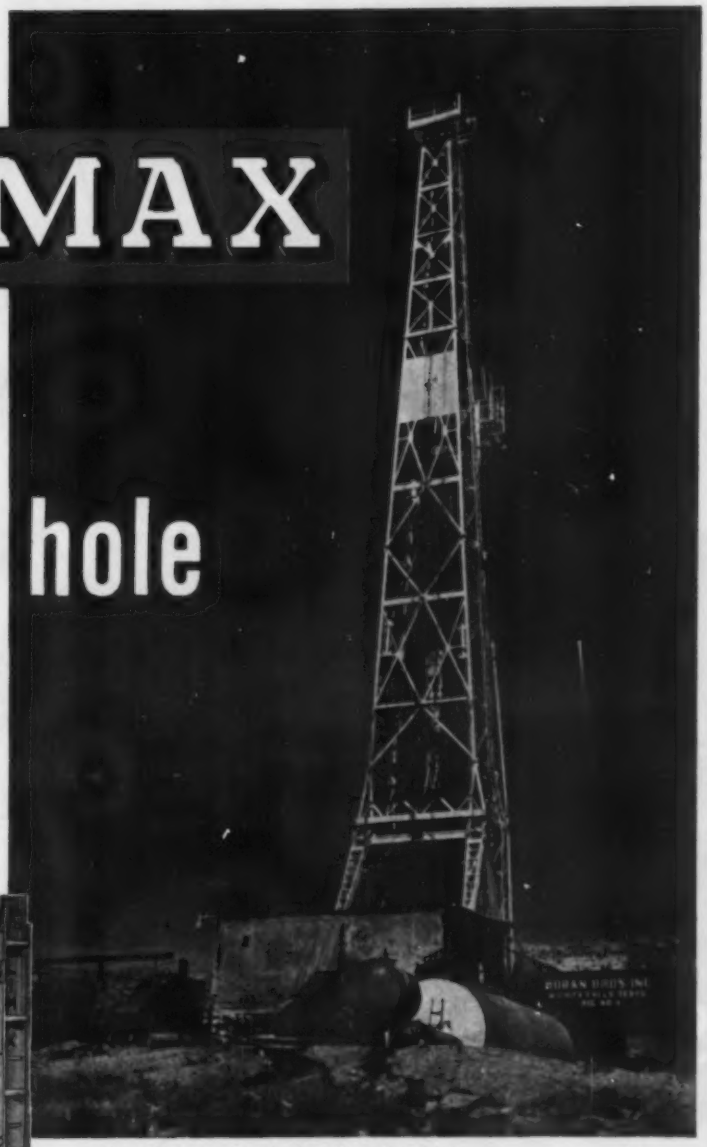
Precautions in handling the pipe during running operations to prevent mechanical damage are important for the same reasons given under "Pre-job planning." Further, to avoid damage,

IT'S CLIMAX

for the 44-inch hole

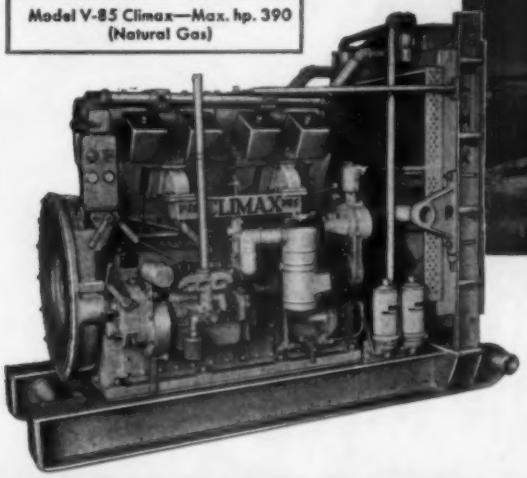
TWO V-85 CLIMAX ENGINES ON TOP
...HANDLE 122 TONS IN THE HOLE

[Reamer bit, four collars, basket, and 965 feet of 13⅜-inch pipe weigh 244,000 pounds in the hole.]



Moran Bros., Inc., Rig No. 3, making 44-inch hole in solid granite, 85 miles north of Las Vegas.

Model V-85 Climax—Max. hp. 390 (Natural Gas)



Climax Engines have proven their reliability in hundreds of oil field installations. Single, well balanced design, rugged construction, and quality materials make them smooth running . . . for years!

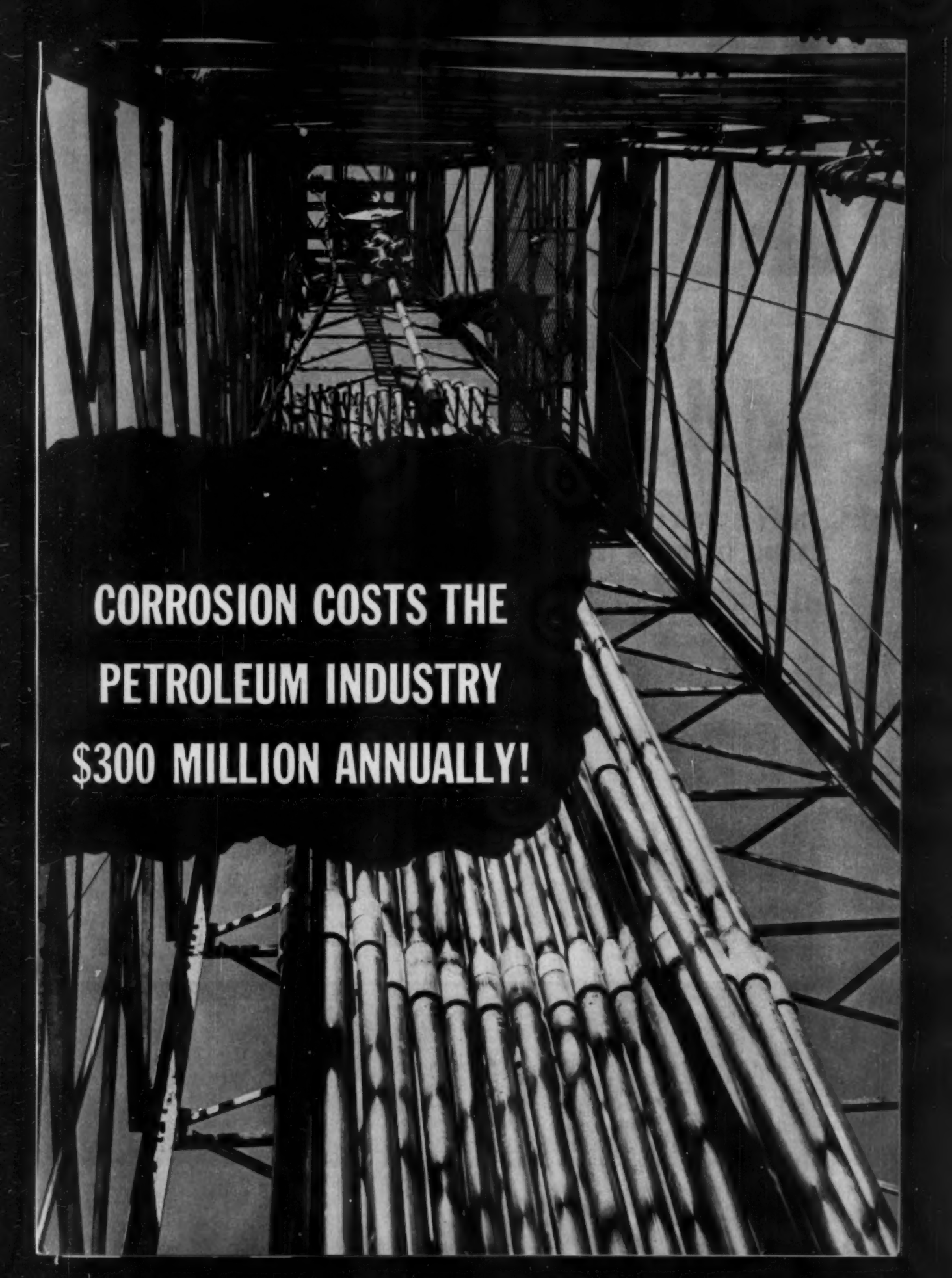
CL-112R

POWER UNIT PUMPING and DRILLING HP—CONTINUOUS DUTY

MODEL	Bore and Stroke	Displacement	Torque @ RPM	BRAKE HORSEPOWER AT SPEEDS INDICATED					
				600	700	800	900	1000	1100
R-165	6⅛ x 7	1238	684 @ 750	81	93	105	117	127	135
K-67	7 x 7	1616	955 @ 805	110	129	145	161	176	188
K-75	7½ x 7	1855	1090 @ 800	126	146	166	185	204	218
V-80	7 x 7	2155	1240 @ 850	140	165	188	210	230	246
V-85	7½ x 7	2474	1440 @ 900	164	194	223	246	266	284
V-122	7 x 7	3232	1915 @ 900	217	258	293	328	353	378
V-125	7½ x 7	3711	2220 @ 850	242	292	340	384	417	442

Write for descriptive literature

CLIMAX ENGINE MANUFACTURING CO. • DIVISION OF WAUKESHA MOTOR COMPANY
FACTORY—CLINTON, IOWA


CORROSION COSTS THE
PETROLEUM INDUSTRY
$300 MILLION ANNUALLY!

...Now You Can Control 96% of All Your Petroleum Corrosion Problems with this Proven PITT CHEM® Coating System!

Corrosion ranks as a major "cost" factor in the production of crude oil and petroleum products. The American Petroleum Institute estimates that corrosion costs the industry 300 million dollars annually, or 11 to 14 cents per barrel of throughput.

From initial exploration, through transportation and storage, Pittsburgh now provides the petroleum industry with a complete system of heavy duty protective coatings formulated to meet specific petroleum corrosion conditions. Service-proven PITT CHEM Coatings save thousands of dollars every day, protecting valuable equipment against sour crudes, condensate, sweet oils and a variety of corrosive environmental conditions.

PITT CHEM Tarset, Tarmastic and Insul-Mastic are tough, *heavy film* coatings that outlast conventional maintenance paints 10 to 20 times. You measure their protection in *decades*, not years. They can be cold-applied by brush, spray gun or roller. No other family of protective coatings can solve so *many* of your corrosion problems so *economically*.

For more information, mail the coupon below. Then consult your nearest PITT CHEM Distributor—he's listed in the "Yellow Pages." Or call Pittsburgh Coke & Chemical Company in Pittsburgh, New York, Chicago, Houston or Los Angeles. A PITT CHEM Corrosion Engineer will be glad to discuss your corrosion problems without obligation.

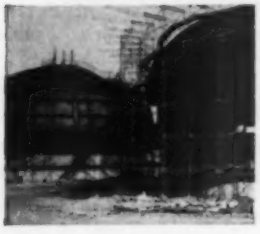
PITT CHEM TARSET®

Tarset, the original, patented, coal tar-epoxy coating, has solved some of the most difficult corrosion problems in the petroleum industry. Applications to crude oil storage tank interiors, gasoline and jet fuel storage tanks, underground pipelines and pipe joints have proven Tarset's protective ability.

PITT CHEM TARMASTIC®

PITT CHEM Tarmastic coal tar coatings are a series of protective coatings designed to meet a wide variety of corrosive conditions at moderate cost. Oil tank exteriors, structural steel, concrete, piling and waste systems are just a few of the many proven applications for Tarmastic coatings.

PITT CHEM INSUL-MASTIC®



Vapor and moisture penetration problems are solved economically and effectively with Insul-Mastic Gilsonite-asphalt coatings. Petroleum plants use Insul-Mastic to protect metal buildings, tanks and equipment. Insul-Mastic insulating mastics provide good heat loss reduction and condensation control.

PITT CHEM PIPELINE ENAMELS

For the long-term preservation of underground pipelines, coal tar enamels are considered the most practical and effective method of protection ever developed. PITT CHEM Pipeline Enamels are widely recognized for their excellent quality and service record on oil, gas and water transmission and distribution lines throughout the nation.

Send for Your Free Copy of this
PETROLEUM CORROSION DATA FILE

Includes a survey of corrosion problems in the Petroleum Industry, data on PITT CHEM Coating Systems and a coating selector guide.

Name_____ Title_____

Company_____

Street_____

City_____ State_____

PROTECTIVE COATINGS DIVISION
PITTSBURGH CHEMICAL CO.
GRANT BUILDING PITTSBURGH 19, PA.
A Subsidiary of PITTSBURGH COKE & CHEMICAL COMPANY

978

the pipe should be carefully stabbed and rotated slowly with low torque at the start of make up. The temperature of the connection during spin-up should be checked as excessive heat is indicative of an improper connection.

Control of proper torque limitations is important. Recommended torque figures are available from different manufacturers on API connections as well as on a manufacturer's own special connection.

A continuous check of techniques during the running operations and continuous inspection of the pipe as run is advisable.

Landing operations. The operations to follow running of the pipe, such as circulating time and movement of pipe to scratch filter cake, should have received prior investigation and accepted practices should be carefully followed.[8]

Following placement of cement and the specified waiting-on-cement time, the pipe is nippled up for its permanent suspension in the well. According to surveys made by API groups, the most widely-followed practice is to suspend the pipe under tensile loading as nearly as practicable to the as-run condition.[9] This should receive careful consideration under unusual circumstances as temperature, internal pressure and reservoir strata conditions could result in casing failure if the pipe is not permanently suspended in the most advantageous manner.

Metallurgical Considerations

Some comments have previously been made regarding notch sensitivity of the higher-alloy materials. The recognition of this undesirable physical property has led to considerable investigation of the role of ductility in oil well tubular goods.[10] There are different viewpoints on what properties of steel are advisable to enable drilling wells to the 25,000 ft plus range and controlling wells that have shut-in pressures in excess of 12,500 psi. Some advocate achieving this through the use of higher-strength materials, while others believe the lower-strength materials with greater wall thicknesses are desirable.

Regarding the higher-strength materials, the properties can best be obtained and controlled by heat treatment — that is, by either normalizing (air cooling) or liquid quenching followed by reheating (tempering) to obtain the desired combination of strength and ductility.

Advocates of the use of lower-strength materials and greater wall thicknesses point to the greater reliability and lower sensitivity to failure of these materials from mechanical damage or manufacturing-induced flaws. In recent years, stress-corrosion cracking, hydrogen embrittlement, and sulfide stress cracking have entered the picture.

This further complicates the selection of the type steel and physical properties. Much investigation must still be made before the answer will begin to emerge.

Regardless of whether deeper drilling and handling of higher wellhead pressures are achieved through higher-strength materials or greater wall thicknesses, it can be stated without reservation that an improved product and greater quality control must be achieved in manufacturing processes if these wells are to be drilled and completed successfully.

Likewise the general practices followed by the users in the handling and application of oil field tubular goods must be improved.

This presentation has not encompassed in any detail the mechanics of designing casing strings and of running casing.

As previously stated, this was not done because of the availability of this information in the referenced material. An attempt has been made, however, to point out and illustrate a few of the things not readily recognizable and associated with the responsibilities of engineers and supervisors in the overall subject of designing casing strings and running casing.

Some of these are economics, delegation of responsibilities, education, and metallurgical aspects. Emphasis on these factors, as well as the mechanics of design and the mechanics of running casing strings, will result in the greatest service to the industry.

APPENDIX 1

Names of Casing Strings and Functions of Each

A. Conductor
   1. Confine circulating fluids
   2. Stabilize the cellar floor and protect the rig foundation
   3. Restrain hole walls in soft or unconsolidated surface formations
   4. Seal off shallow water flows
   5. Prevent loss of circulation

B. Surface
   1. Protect fresh water sands from contamination
   2. Provide foundation for blowout preventers and later the wellhead
   3. Confine shallow charged zones if encountered
   4. Support subsequent casing and tubing strings
   5. Prevent loss of circulation

C. Protector
   1. Prevent hole sloughing
   2. Prevent loss of circulation of heavy muds required for drilling the deep high pressure zones
   3. Protect against loss of drill string in "sticky" or key seated holes
   4. Prevent hole enlargement in salt sections. This allows later drilling to be done with preferred fresh water muds.
   5. Protect subsequent strings from external corrosion
   6. Confine well if mud weight inadequate to overbalance unexpected pressure

D. Production String
   1. Protect drilled hole during productive life of the well
   2. Isolate permeable horizons thus preventing migration of fluids
   3. Protect all required down hole equipment
   4. Permit selective production of fluids from only the oil or gas bearing portion of a reservoir
   5. Provide control of a well should the tubing fail

E. Liner
   1. Protect drilled hole below string last run to permit:
      a. Deeper drilling or,
      b. Isolation of horizons to prevent migration or to enable selective completion
   2. Possible high top hole pressure and high mud weight limits use
   3. Usable when other conditions can be adequately met by string last run

APPENDIX 2

Forces to be Considered in Design

A. Buckling
   1. Most applicable in conductor and surface strings
   2. Length of column makes it impractical to design against buckling in other strings
   3. Buckling forces can be reduced by
      a. Not setting string down on bottom or on bridges while running

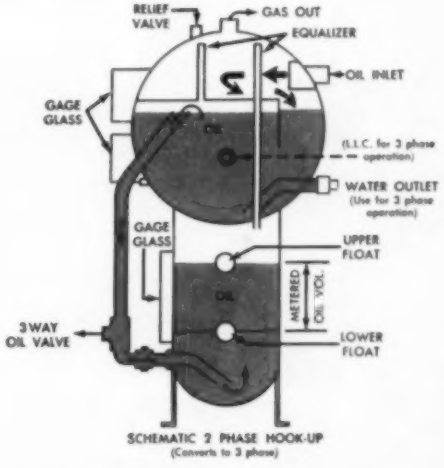
TYSCO

the spherical metering separator with built-in utility

. . . easily converts from 2 to 3 phase.

A standard 2 phase Tysco Spherical Metering Separator not only records oil volume accurately and separates oil and gas efficiently, but, by simply adding an interface controller and control, it is easily converted to a 3 phase unit for separating oil, gas, and water. Internal baffles assure minimum turbulence and maximum operating capacities. Each unit is equipped with a non-bleed, 2-float meter switch, field-proven to give dependable performance even on paraffin service. The overall size and low silhouette of Tysco Spherical Metering Separators reduce space requirements, installation time, and handling problems.

For full information on Tysco metering equipment: Spherical or Vertical Metering Separators (2 and 3 phase) and Metering Vessels (for metering liquids as a subsequent operation to existing equipment) contact your local Tysco sales engineer, or write:



TYSCO **TYSON SMITH CO.**

P. O. BOX 7398 • HOUSTON 8, TEXAS

SALES OFFICES: Corpus Christi, Dallas, Houston, McAllen, Odessa, and San Antonio, Texas; Lafayette and New Orleans, Louisiana; Laurel, Mississippi.
EXPORT SALES: Ideco, Inc.

One of the Smith Industries

Serving Industry With Quality Products, Dependable Service.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

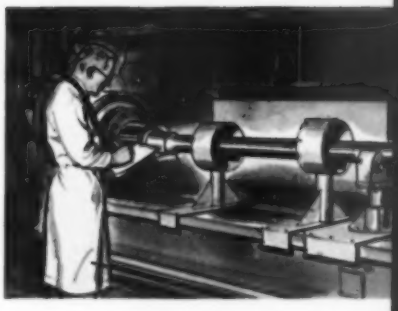
There has never been a field failure in the weld area of a Reed Flash Welded tool joint!

ANOTHER EXAMPLE OF REED LEADERSHIP IN TOOL JOINT DESIGN

For twenty-five years Reed has pioneered advancements in tool joint design—the Shrink-Grip joint which practically eliminated last engaged thread failures—the Internal Flush joint that became API Standard—the Double Streamline joint (the 4½" size later adapted as API Standard 4" Full Hole)—the Semi-Internal Flush joint (later called Extra Hole)—the Super Shrink-Grip joint with cylindrical land and fixed landing shoulder for foolproof field application and removal—the Wide-Open joint for light weight drill pipe—the "tensile impact" test for flash welds.

Reed research, engineering, and experience are your assurance of the very best in tool joints today *and* tomorrow.

When you buy your next string, remember this—Reed Tool Joints will outlast any others!



ask about the new Reed
Inarclad 60

REED

SUPER SHRINK-GRIP AND FLASH WELDED
TOOL JOINTS

REED ROLLER BIT COMPANY
Houston 1, Texas
EXPORT OFFICE: 1011 INTERNATIONAL BLDG., NEW YORK 20, N. Y.
GULF COAST, MID-CONTINENT, ROCKY MOUNTAIN AND CANADIAN DISTRIBUTOR FOR MARTIN-DECKER PRODUCTS

new analysis shows how to-

cut drilling costs by $200 per day

If you are using mud as heavy as 12 lbs. per gallon, here is an engineering analysis that shows how you can cut mud costs by using a CLAYJECTOR®.

12-pound mud generally contains about 1½ sacks of barite per barrel. Every time you jet a barrel of mud, you lose barite as well as the clays you are trying to get rid of. This means a monetary loss of over $3.50 per barrel.

Now, if you use three steel tanks, you lose about 100 barrels of mud every time you jet down one foot. Since it is common practice with muds in the 12-pound range, to jet at least one foot per day, that means you jet away something like $400.00 worth of barite, oil and chemicals. With heavier muds, there will probably be less jetting. However, the greater amount of barite and chemicals per barrel means an even greater loss by jetting. You can avoid that loss if you use the CLAYJECTOR to process your mud — rejecting unwanted clays and retaining expensive barite.

Since you get more than 70 per cent clay rejection efficiency with the CLAYJECTOR, you need process only 140 barrels of mud to reject the equivalent of all the clay from about 100 barrels of mud. This low volume of fluid processed keeps oil and chemical losses at a minimum.

Because barite recovery efficiency is 80 to 90 per cent, you lose less than one fifth of the barite in the mud being processed — a negligible amount out of the whole system.

To summarize, you save over $300 for every 100 barrels of mud you would have jetted — if you use the CLAYJECTOR instead of jetting. *Even when you deduct the cost of the CLAYJECTOR, you still can save well over $200 per day.*

This example may not apply precisely to your conditions, but your nearby Swaco sales engineer is ready to help you estimate your probable saving. Call him for more information.

SWACO®

SALT WATER CONTROL, INC.

1809 Continental National Bank Bldg.
Phone: ED 2-4433
Ft. Worth 2, Texas

b. Supporting the casing with cement

c. Correct landing procedure after cementing

B. Tensile

1. Weight of casing string
2. Impact due to sudden starts or stops
3. Internal pressure causing elongation
4. Temperature changes causing contraction with both ends of string fixed

C. External Pressure (Collapse)

1. Differential weight of fluid column or formation pressure
2. Plastic flow of salt sections
3. Shifting of earth's strata

D. Internal Pressure (Burst)

1. Most applicable in production and protection strings
2. Differential weight of fluid column
3. Resulting from tubing or inner string failure
4. Impending blowout
5. Well stimulation treatment, such as acidizing or fracturing

Bibliography

1. Peret, J. W., "Casing String Design, Handling and Usage," Fundamentals of Oil and Gas Production, *The Petroleum Engineer*, Third Edition, June, 1959
2. McCray and Cole, *Oil Well Drilling Technology*, University of Oklahoma Press, Chapter 19
3. "Performance Properties of Casing and Tubing," API Bulletin 5C2
4. Spang Engineering Data Book, Section 1
5. "Casing String Design Factors," A report of the API Mid-Continent District Study Committee on Casing Programs, March, 1955, Paper No. 851-29-I
6. "Care and Use of Casing, Tubing and Drill Pipe," API RP 5G1 (50 cents)
7. Texter, H. G., "Oil Well Casing and Tubing Troubles," API Southwestern District Meeting, March, 1955
8. "Oil Well Cementing Practices in the United States," API, 1959, Chapters 8, 9 and 16
9. "Casing Landing Recommendations," API Southwestern District Study Committee, 1955, API Bulletin D7
10. Prange, F. A., and Hebard, G. G., "The Role of Ductility in Oil Well Tubing and Casing," API Mid-Continent District Meeting, March, 1955

★ ★ ★

APPENDIX 3

THREE 15,000-FT 5½-IN. OD CASING STRING DESIGNS

Footage	Weight per ft	API grade	Type connection	Weight of section-lb	Accumulated weight lb	Design Factor tension	Design Factor collapse
DESIGN 1							
1600	23#	N-80	LT&C	36,800			1.19
2390	20#	N-80	LT&C	58,600	95,400	Hi	1.125
6170	17#	N-80	LT&C	104,900	200,300	1.60	1.125
1950	20#	N-80	LT&C	39,000	239,300	1.60	Hi
1610	23#	N-80	LT&C	37,000	276,300	1.60	
740	23#	N-80	Special	17,000	293,300	1.82	
DESIGN 2							
3600	23#	P-110	Special	82,800			1.72
3600	23#	N-80	LT&C	82,800	165,600	3.17	3.03
7800	23#	P-110	Special	179,400	345,000	1.93	
DESIGN 3							
15,000	23#	P-110	Special	345,000	345,000	1.93	1.72

NOTE: Sections listed in order from bottom to top.

Free to Subscribers!

Don't forget

to order your

1959 Annual Index.

Write The Petroleum Engineer,

Box 1589

Dallas 21, Texas

Service with ACTION

WHEN YOU SPECIFY-

W.C. NORRIS SUCKER RODS

Write for complete Sucker Rod Bulletin

W. C. NORRIS, MANUFACTURER

DIVISION OF DOVER CORPORATION

P. O. BOX 1739 • TULSA, OKLAHOMA

BRANCHES: Great Bend, Kansas; Corpus Christi, Houston, Kilgore, Odessa, Wichita Falls, Texas; Oklahoma City, Oklahoma; Salem, Illinois; Casper, Wyoming; Farmington, New Mexico; Edmonton, Alberta, Canada.

NORRIS QUALITY SUCKER RODS

Buy From Your NORRIS Distributor

Part 1

Simplified Log Interpretation

Technique uses focused devices to produce single curve that easily determines fluid saturation in a zone of interest by measuring true resistivity and porosity

Terry Walker,
Welex, Inc.
Fort Worth, Texas

IN ORDER to accurately evaluate any well, it is necessary to answer two questions. First, what is the porosity of the formation, and second, what is the percent of fluid saturation?

These answers can be found easily from the log by the well operator after he determines two factors — is the drilling mud in the well such that the mud filtrate resistivity is close to that of the formation water, and what type of porosity is present in the zones of interest in the well?

Basically, log interpretation is based upon comparison of the true resistivity (Rt) of a zone with the resistivity it would have if it contained formation water only (Ro). Fig. 1 shows a schematic diagram of the variation of resistivity with distance from the bore hole wall. As illustrated, for a water zone the relative resistivity of the first few inches of the formation, Rxo, compared to Ro depends only upon the contrast between the resistivity of the mud filtrate and the formation water (Rmf/Rw). If Rmf/Rw = 3, then Rxo is three times Ro; if Rmf/Rw = 5, then Rxo = 5 Ro.

Neglecting residual oil saturation in the flushed zone, the same is true for an oil zone, but the resistivity of the undisturbed oil zone will be considerably greater than Ro, 31.6 percent water for Rt = 10 Ro, and 25 percent water for Rt = 16 Ro. The Rmf/Rw ratio immediately tells the analyst what the contrast should be between the resistivities indicated by shallow and deep investigation tools in a water zone.

Therefore, the importance of the first question — the contrast between mud filtrate and formation water resistivity — cannot be emphasized too strongly. It can be obtained from known data in the area *or from the SP curve.*

As discussed, this Rmf/Rw ratio governs the effect of invasion upon the logging tools, which in turn governs the choice of the logging tool that should be used for the determination of Rt.

The characteristics of the guard tool are such that it tends to be affected mostly by the higher resistivity present, either invaded zone or Rt. The characteristics of the induction tool

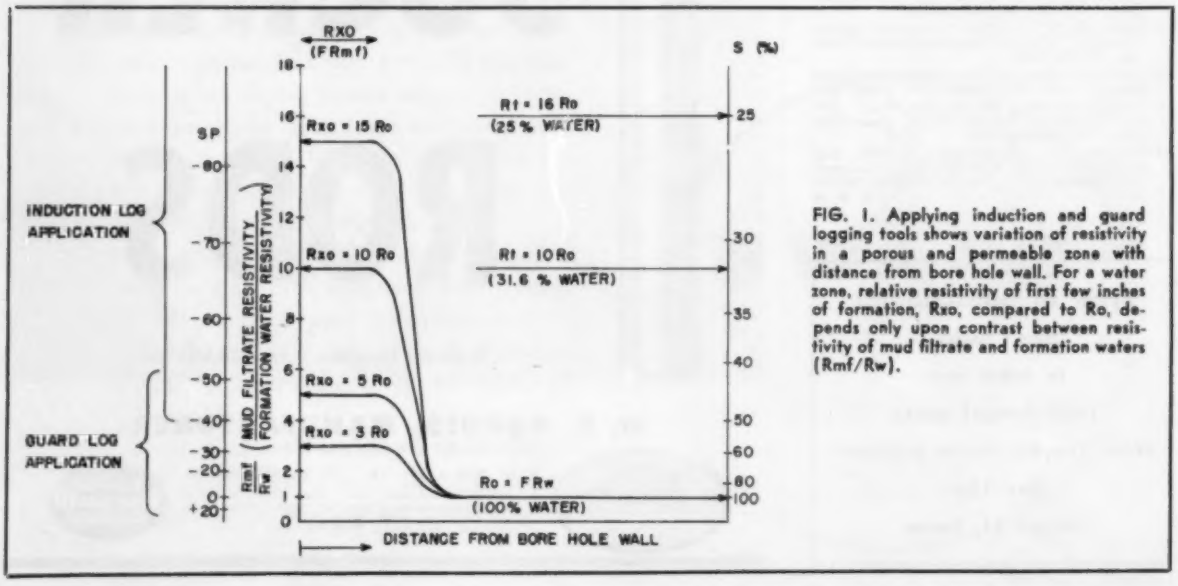


FIG. 1. Applying induction and guard logging tools shows variation of resistivity in a porous and permeable zone with distance from bore hole wall. For a water zone, relative resistivity of first few inches of formation, Rxo, compared to Ro, depends only upon contrast between resistivity of mud filtrate and formation waters (Rmf/Rw).

Let Mid-Continent supply your exact needs with

ENGINEERED PRODUCTION EQUIPMENT INSTALLATIONS

When you buy production equipment from Mid-Continent Supply Co., you know you're getting equipment that's right for the job. Mid-Continent unit installations are *engineered* for your exact needs, to your specifications. And Mid-Continent offers a single source of supply and service to keep your equipment operating efficiently from the first barrel to the last.

For complete information on the operating economy of top quality, engineered production equipment, call your nearest Mid-Continent sales engineer. Let him explain what we can do for you . . . around the clock . . . around the world.

MID-CONTINENT - SUPERMARKET FOR THE OIL INDUSTRY

UP1-O

MID-CONTINENT SUPPLY CO.

THE WORLD'S LARGEST INDEPENDENT OIL FIELD SUPPLY COMPANY

Mid-Continent Building, Fort Worth, Texas • Export Division: 45 Rockefeller Plaza, New York 20, N.Y. Cable: MIDCUMPORT NYK

You save drilling dollars with

THE

MUD PROBLEM: Maintain a stable bay-water mud to drill through hydratable shales and formations containing high pressure gas and salt water.

WELL DATA

Location: Timbalier Bay Field, Lafourche Parish, Louisiana
Total Depth: 15,376′

MUD ADDITIVE PROGRAM

0′ to total depth	Q-BROXIN*, BAROID**, bay water, caustic soda, gypsum.
12,876′	Mud density increased to 12.3 ppg; Q-BROXIN treatment increased; Baroid Mud Centrifuge installed.
13,276′	FINE MICATEX**, and other lost-circulation materials added, maintained to total depth.
14,302′	Diesel oil added, maintained at 6% to 10% by volume to total depth.
14,510′	TRIMULSO** (0.5 lb/bbl) and E P MUD-LUBE†, (4.0 lb/bbl) added, maintained to total depth.

TYPICAL MUD PROPERTIES

Depth, feet	12,950	13,464	14,064	14,510	15,003	15,376
Weight, ppg	12.1	12.5	13.3	14.3	15.6	16.6
Ave. sp gr, solids	2.8	3.0	3.0	3.2	3.8	3.7
Viscosity, sec. API	55	48	54	66	58	65
Stormer Gel, 10 min	25	25	20	10	7	15
Filtrate, ml, API	5.5	4.9	3.9	1.6	1.8	1.2
pH	10.9	10.4	11.1	10.4	10.2	10.6
Chloride, ppm (1000's)	19	23	21	23	22	23
Oil, %	0	0	0	6	9	7

CASING PROGRAM

Size Inches O.D.	*Depth Set Feet*
13⅜	6,464
9⅝	14,871

DISCUSSION: Major difficulties were anticipated below 14,000′ because of gas-bearing hydratable shales. Side wall coring, electric and induction logging and similar operations required an exceptional mud program. Salty bay water was used for making-up the liquid phase of the mud.

SOLUTION: Q-BROXIN mud was chosen as the basic mud additive from surface to total depth. The treated mud had a high degree of tolerance for solids, an inhibitive effect on hydratable shales and was not greatly affected by contaminants. BAROID was added to maintain weight, and FINE MICATEX was used to maintain good hole condition below 14,500′.

Total mud cost was about one-half the cost of previous wells of similar depths. 14,871′ of 9⅝″ casing was successfully set and cemented, the deepest of this size in this field. Side wall cores and good logs were obtained without difficulty.

**Registered Trademark, Baroid Division National Lead Company
†Trademark, Baroid Division National Lead Company
*Registered Trademark of Puget Sound Pulp and Timber Company

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

a Baroid Mud Program

MUD PROBLEM

... and its solution

Total mud costs were cut in half and tight-hole problems were solved in this typical case history of a Baroid mud program. Through experienced engineering skill, a combination of Baroid mud additives were matched against a combination of down-hole conditions with successful results.

Gas pressure, salt contamination and tight-hole conditions were expected at depths below 14,000′. Side wall coring and electrical logging were desired. Using a bay-water — Q-BROXIN mud, frequent pilot testing, and special-purpose Baroid additives permitted successful drilling of the well and setting 9⅝″ casing to a record depth in this field.

This demonstration is repeated daily in every major oil area. Baroid's improved concept of mud marketing is winning approval. By integrating material production, engineering research and distribution into a single chain, administered with utmost integrity, Baroid solves your problems and *saves your drilling dollars.*

RESISTS ANHYDRITE CONTAMINATION
OVERCOMES EFFECTS OF SALT WATER
KEEPS MUD STABLE AT HIGH TEMPERATURE
KEEPS MUD DEFLOCCULATED

BAROID

BAROID DIVISION NATIONAL LEAD COMPANY

MAIN OFFICE: P. O. BOX 1675, HOUSTON 1, TEXAS

6008

usi **Axelson** **PUMPING NEWS**

Axelson Increases Pump Life

Hardened Barrel Tube is flame-hardened to a uniform minimum depth of .025". Finish on all tubes and plungers is controlled to provide maximum lubricating qualities, retains oil.

Finest Automatic barrel tube honing equipment in industry has a built-in micrometer which makes a pass through the tube with each stroke of the hone. Automatically stops machine when desired I.D. tolerance is achieved.

Looking to New Slim Hole Completions?

Contact your Axelson man about new slim hole developments. Typical is Axelson's Thru-Hard coupling for slim hole production. It's used in place of a hardened and ground coupling. The Thru-Hard coupling has a built-in toughness without sacrifice of strength. Try it and see.

Write Today for New Literature

Box A
Axelson Division
U. S. Industries, Inc.
6160 So. Boyle Avenue
Los Angeles 58, California

- ☐ New Hard-Faced Axite Plunger
- ☐ Slim-Hole Pump
- ☐ 1960 Composite Catalog

NAME_____

COMPANY_____

ADDRESS_____

Longer Pump Runs Result From Barrel Tube And Plunger Manufacturing Developments

Equipment life and production runs can be increased through better barrel tubes and plungers in proper combination. Axelson field representatives are trained to prevent customers from paying for a premium tube or plunger when it may be unnecessary, because, in many cases, a more economical combination may be available. In addition, Axelson has spent thousands of dollars improving manufacturing techniques to produce the most complete selection of barrel tubes and plungers available. Here are the facts:

Barrel Tubes—Axelson's hardened tube has the heaviest case known for maximum wear resistance. It is combined with a strong, resilient, tough outside diameter. Only the I.D. is case-hardened. Threaded ends are unhardened to retain their inherent toughness.

A uniform case depth and hardness is maintained, eliminating soft spots. Axelson helped steel companies develop non-destructive ferro testing to avoid split tubes. Quality is upheld through concentricity, straightness, finish and closely maintained tolerances.

Unhardened tubes are produced for mildly corrosive wells, etc. Exceptionally hard chrome I.D. tubes are available for salt water type corrosion conditions, particularly where abrasion is a problem.

Plungers—The best runs are accomplished by a proper combination of tube and plunger. A careful choice of both is necessary. Axite, chromium plated, hardened steel, regular steel, niaxite, and composite (eutectic, regular iron, hard cast iron) plungers are produced by Axelson to give production men as wide a selection of equipment as possible.

For example, Axelson's Axite plunger surfaces are highly resistant to abrasion, impervious to salt water, extremely resistant to hydrogen sulphide, and non-galling (lowest coefficient of friction of any type plunger available). Axite particles have a hardness of 9 on the Mohs Scale. They are best for extremely corrosive conditions.

Field Tested—A highly abrasive and corrosive California well in the Bakersfield oil field had consistently chewed up ordinary plungers (such as one shown at right) in a matter of several weeks. Axite plungers were finally installed. The Axite plunger shown at left ran 25% longer than the best previous plunger.

© 1960—U.S. Industries, Inc., Los Angeles, Calif.

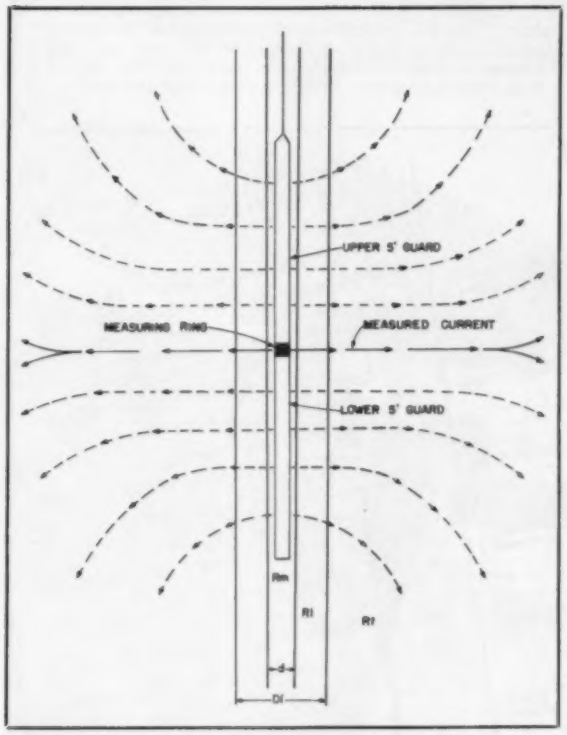


FIG. 2. Guard tool utilizes two 5-ft guards to focus current from a 3-in. measuring ring and force it to flow horizontally into formation as a thin sheet.

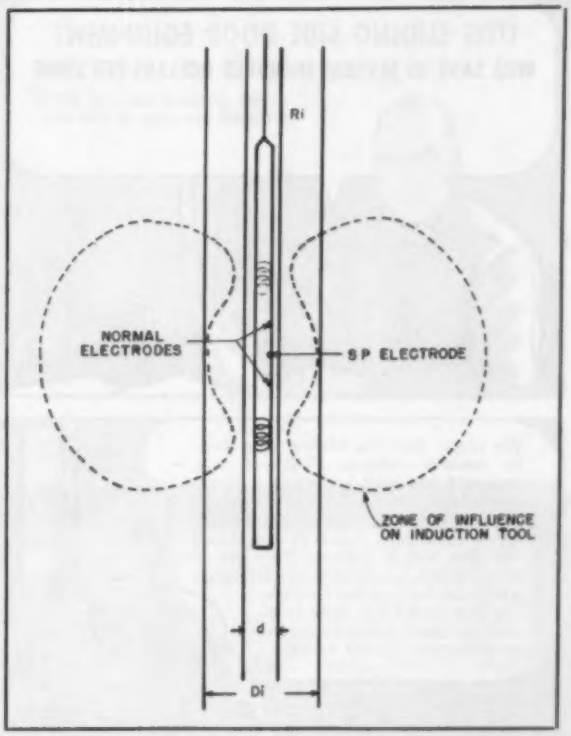


FIG. 3. Only main coils of induction tool are shown, one transmitter and one receiver. Alternating magnetic field induced by main transmitter coil sets up alternating current flow circularly around well bore. Main receiver coil measures secondary magnetic field set up by alternating current flow in formation.

are such that it tends to be affected mostly by the lower resistivity present, either invaded zone or Rt. Fig. 1 shows the area of application for each of these two tools, as measured by the SP values expected or the Rmf/Rw ratios.

The guard log application is in the area where the SP is 50 to 55 millivolts or less (negative deflection from the shale base line), which is a Rmf/Rw of 6 or less. The induction log application is in the area where the SP is greater than 40 millivolts (negative deflection) which is a Rmf/Rw ratio of 4 or more. As shown by the figure, whenever the Rmf/Rw ratio is 6 or less, Rxo is six times Ro or less, but Rxo is still less than Rt for a zone containing producible hydrocarbons.

Under these conditions the guard will read very close to Rt for either oil or water zones with very little effect from invasion. This side effect from invasion can be taken into consideration by departure curves built into a simple fluid saturation chart attached to the log. Whenever the Rmf/Rw ratio is 4 or more, Rxo is sufficiently greater than Ro so that the effect of normal invasion on the induction tool is negligible.

It is still sufficiently close to Rt for a zone containing producible hydrocarbons so that again there is little effect from normal invasion and this can also be taken into consideration by departure curves built into an easily-used fluid saturation chart attached to the log. These fluid saturation charts are based upon the ratio Rxo/Rt and do not require any assumption of cementation exponent for saturation calculations.

The effect of bed thickness is, of course, greater than that previously discussed — the guard log will read a value that can be converted to Rt in zones 1½-ft thick or greater. The induction log will give a value approaching Rt in zones 5½ ft thick or greater when the resistivity of the surrounding beds is less than that of the zone of interest.

The same is true in zones 3 ft or greater when the resistivity of the surrounding beds is greater than that of possible pay zones. In general, the first condition (5½ ft thick or greater) exists when the zones of interest are bounded by shale, and the latter condition (3 ft thick or greater) exists when the zones of interest are bounded by dense lime or dolomite.

The second question — what type of porosity is present — can usually be answered from geological knowledge of the area, whether it is the intergranular type such as is found in sandstone or in crystalline limestone, or the fractured or vugular type.

On the basis of the porosity type, either the FoRxo or neutron log should be used — in general, the FoRxo for the intergranular and the neutron for the fractured or vugular type.

Of course, there will be some overlapping of the two types of porosity logs, such as in clean crystalline limestone where the neutron gives good porosity values. Fractured or vugular formations present a difficult logging problem. If the fractures or vugs are extremely random, the usual Archie saturation calculation $S^n = \frac{Ro}{Rt}$ will not apply as it was developed for intergranular porosity.

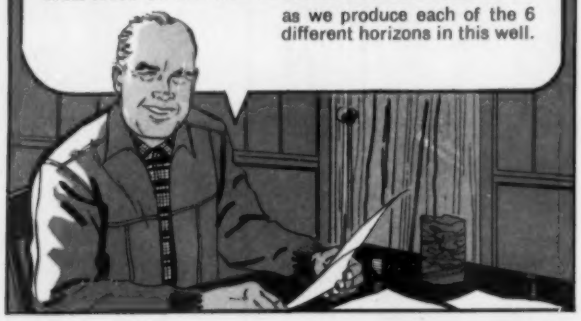
But when the fractures and vugs are interspersed, the intergranular condition is approached and the equation can be applied.

The FoRxo log is essentially recording Rxo with negligible effect from reasonable mud cake thickness. Since Rmf is known, the FoRxo scale can be relabelled as porosity, using an estimated cementation exponent for the formation factor-porosity relationship. As core data becomes available in a field, this relationship can be refined to give porosity more accurately.

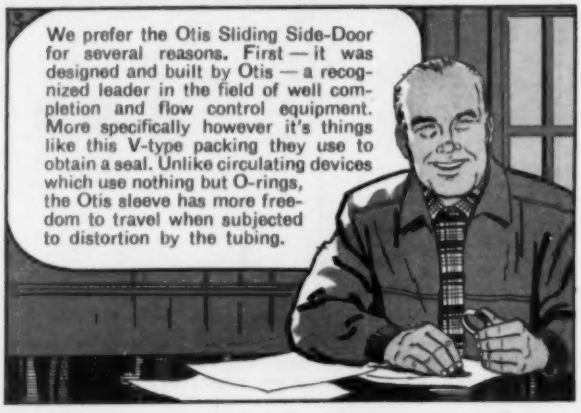
OTIS SLIDING SIDE-DOOR EQUIPMENT

WILL SAVE US SEVERAL HUNDRED DOLLARS PER ZONE

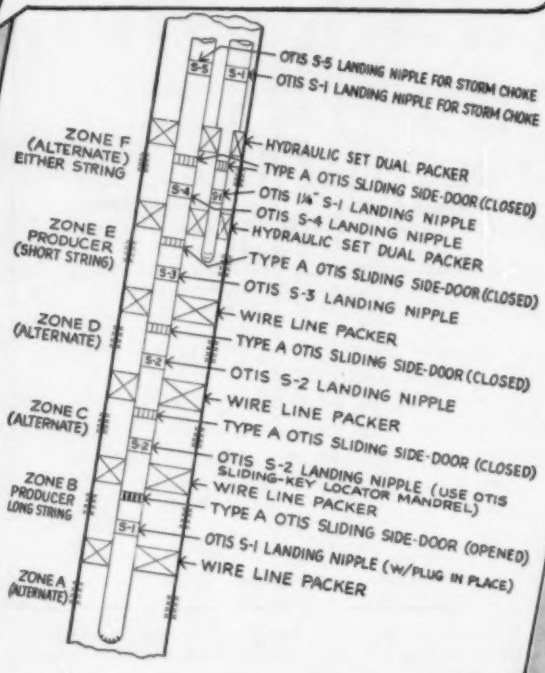
as we produce each of the 6 different horizons in this well.



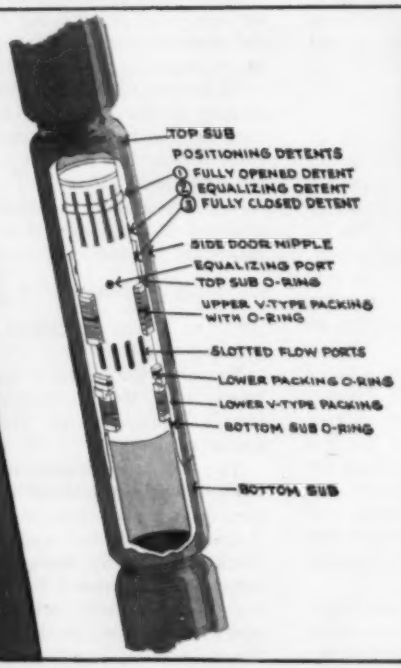
We prefer the Otis Sliding Side-Door for several reasons. First — it was designed and built by Otis — a recognized leader in the field of well completion and flow control equipment. More specifically however it's things like this V-type packing they use to obtain a seal. Unlike circulating devices which use nothing but O-rings, the Otis sleeve has more freedom to travel when subjected to distortion by the tubing.



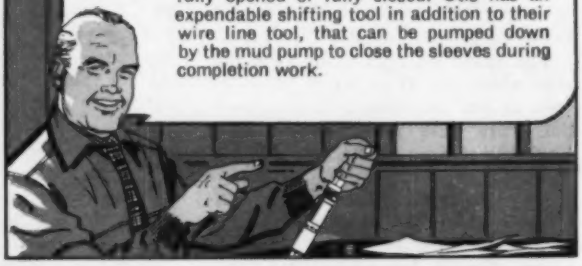
Add to that the thousands of dollars we saved by drilling only one well to produce these 6 formations and you'll see why we're sold on multiple-zone wells and Otis Sliding Side-Door Equipment. Here's a diagram of the well.


S-5
S-1
OTIS S-5 LANDING NIPPLE FOR STORM CHOKE
OTIS S-1 LANDING NIPPLE FOR STORM CHOKE
ZONE F (ALTERNATE) EITHER STRING
HYDRAULIC SET DUAL PACKER
TYPE A OTIS SLIDING SIDE-DOOR (CLOSED)
S-4
OTIS 1¼" S-1 LANDING NIPPLE
OTIS S-4 LANDING NIPPLE
ZONE E PRODUCER (SHORT STRING)
HYDRAULIC SET DUAL PACKER
TYPE A OTIS SLIDING SIDE-DOOR (CLOSED)
S-3
OTIS S-3 LANDING NIPPLE
ZONE D (ALTERNATE)
WIRE LINE PACKER
TYPE A OTIS SLIDING SIDE-DOOR (CLOSED)
S-2
OTIS S-2 LANDING NIPPLE
ZONE C (ALTERNATE)
WIRE LINE PACKER
TYPE A OTIS SLIDING SIDE-DOOR (CLOSED)
S-2
OTIS S-2 LANDING NIPPLE (USE OTIS SLIDING-KEY LOCATOR MANDREL)
ZONE B PRODUCER LONG STRING
WIRE LINE PACKER
TYPE A OTIS SLIDING SIDE-DOOR (OPENED)
S-1
OTIS S-1 LANDING NIPPLE (W/PLUG IN PLACE)
ZONE A (ALTERNATE)
WIRE LINE PACKER

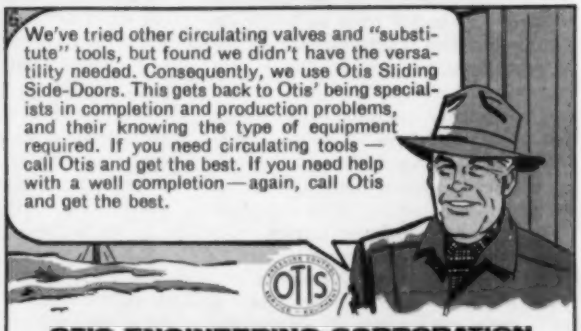
Then there's Otis' vertical slotted port design. This gives Otis Sliding Side-Doors maximum strength — and acts to prevent distortion of the tools as they are subjected to the stress and torque of a production string. Models with special pump-out plugs are also available to let you test your packer before nippling up the tree. Check the design advantages in this drawing.



Another advantage of this Otis equipment is that with their shifting tool they can open and/or close one or several sleeves with just one trip of the wire line. And you're sure the sleeves are fully shifted, too. Otis' shifting tools won't release until the sleeves are either fully opened or fully closed. Otis has an expendable shifting tool in addition to their wire line tool, that can be pumped down by the mud pump to close the sleeves during completion work.



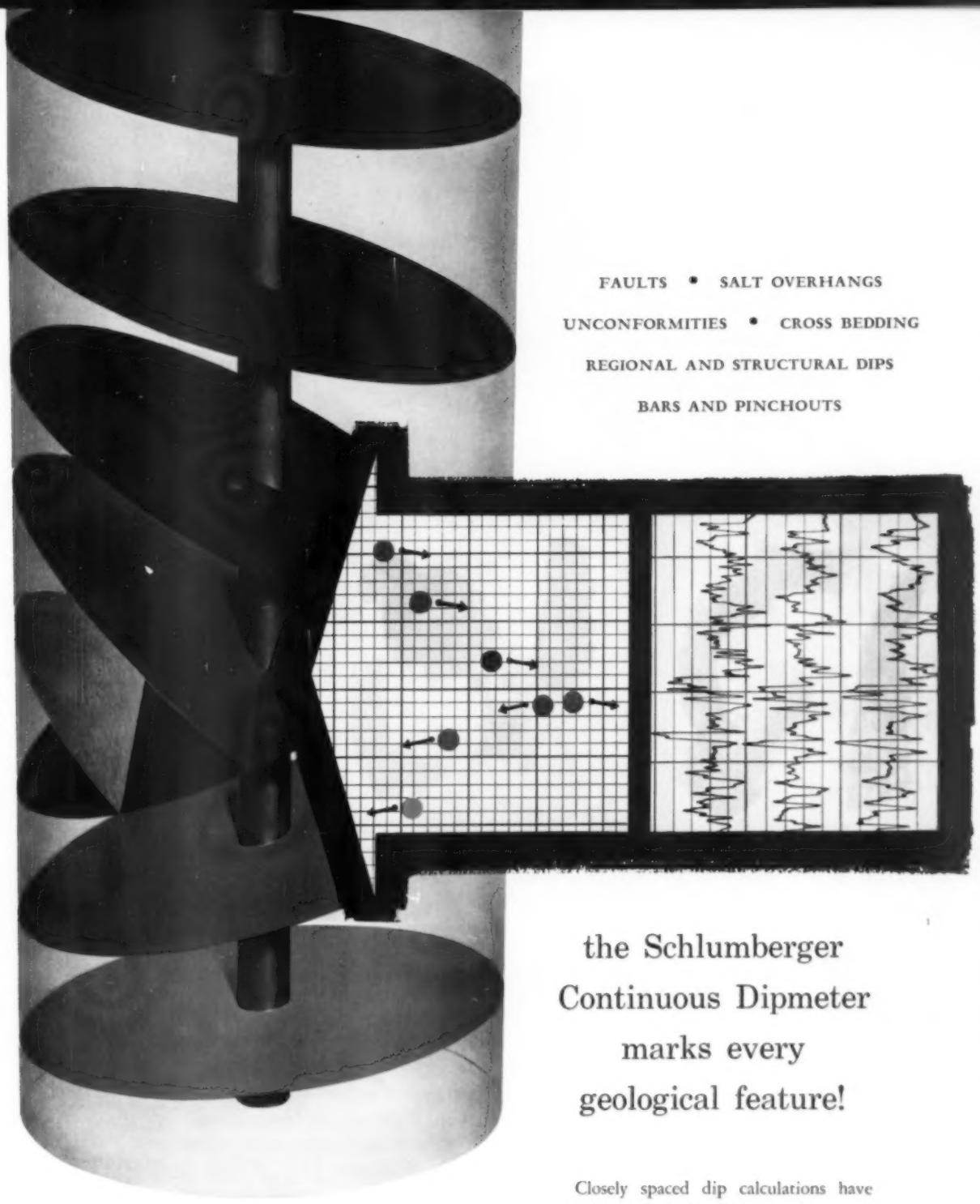
We've tried other circulating valves and "substitute" tools, but found we didn't have the versatility needed. Consequently, we use Otis Sliding Side-Doors. This gets back to Otis' being specialists in completion and production problems, and their knowing the type of equipment required. If you need circulating tools — call Otis and get the best. If you need help with a well completion—again, call Otis and get the best.



OTIS ENGINEERING CORPORATION

General Offices: 6612 Denton Drive · Dallas

Branches Throughout the Oil Country



FAULTS • SALT OVERHANGS

UNCONFORMITIES • CROSS BEDDING

REGIONAL AND STRUCTURAL DIPS

BARS AND PINCHOUTS

the Schlumberger Continuous Dipmeter marks every geological feature!

Closely spaced dip calculations have clearly marked the fault on the graph above. Other structural or depositional features are likewise recognizable by their characteristic dip patterns.

The Continuous Dipmeter gives you a wealth of geological information from a single bore hole. Call your nearest Schlumberger engineer for a discussion of the outstanding results obtained with the Continuous Dipmeter.

THE EYES OF THE OIL INDUSTRY*

SCHLUMBERGER

Unaflo oil-well cement,

CEMENTING DATA

Job – Hattie S. Welch #1, Jefferson Davis Parish, South Louisiana

Drilling Contractor – The Bullard Drilling Co., Inc., Houston, Texas

Owner – Austral Oil Company Incorporated, Houston, Texas

Job #1 – 7⅝" O.D. casing string set at 10,277' in 10⅝" hole, cemented with 500 bags UNAFLO cement plus 6% gel (slurry wt. 14.7 lbs/gal.) followed by 200 bags UNAFLO cement neat, (16.3 lbs/gal.). Drilling mud wt. 13.4 lbs/gal. Schlumberger temp. log 181° F. Est. static BHT 213° F.

Job #2 – 5½" O.D. liner, 2,146' long, bottomed at 12,000' in 6¾" hole cemented with 320 bags neat UNAFLO cement. Drilling mud wt. at cementing 16.4 lbs/gal. Schlumberger temp. log 255° F. at 12,160'. Est. static BHT 265° F.

Job #3 – 5½" O.D. full casing string tied to top of 5½" O.D. liner, using liner to casing coupling with 100 bags neat UNAFLO cement.

compatible with various additives...

UNAFLO oil-well cement is successfully used neat or with various types of additives in more and more cementing operations. For cementing casing or liner, squeeze cementing, plug-backs or recementing, UNAFLO cement slurries pump easily and set hard to provide an adequate seal. Its retarded set sustains high initial fluidity despite high temperatures and pressures. This allows time for proper placement plus a margin of safety for delays or emergencies.

For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

Universal Atlas Cement
Division of
United States Steel

U-163

"USS" and "Unaflo" are registered trademarks

OFFICES: Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco

Summary

Saturation determinations require two primary measurements from logs — true resistivity and porosity. The simplified logging technique is based upon the focused devices so that each measurement comes from just one curve with little or no corrections required. These measurements allow saturation determination without any laborious calculation procedures.

The charts give the same results as the longer methods plus allowing the user to see at a glance the effect of invasion diameter and various Rmf/Rw ratios on the resulting saturation determination. In addition, the porosity scale is scaled directly on the FoRxo and neutron log.

This procedure allows detailed saturation and porosity determinations over long sections in a minimum amount of time.

Principles of the Four Logging Tools Involved

Guard tool. Diagram of the guard tool, Fig. 2, shows the principles of operation. The current from a 3-in. ring is focused and forced to flow horizontally as a thin sheet by 5 ft guards above and below. These guards are kept at the same potential as the 3-in. ring, but only the current from the ring is measured, so that the resulting resistivity reading on the log is a measurement of everything in the path of the thin sheet of current.

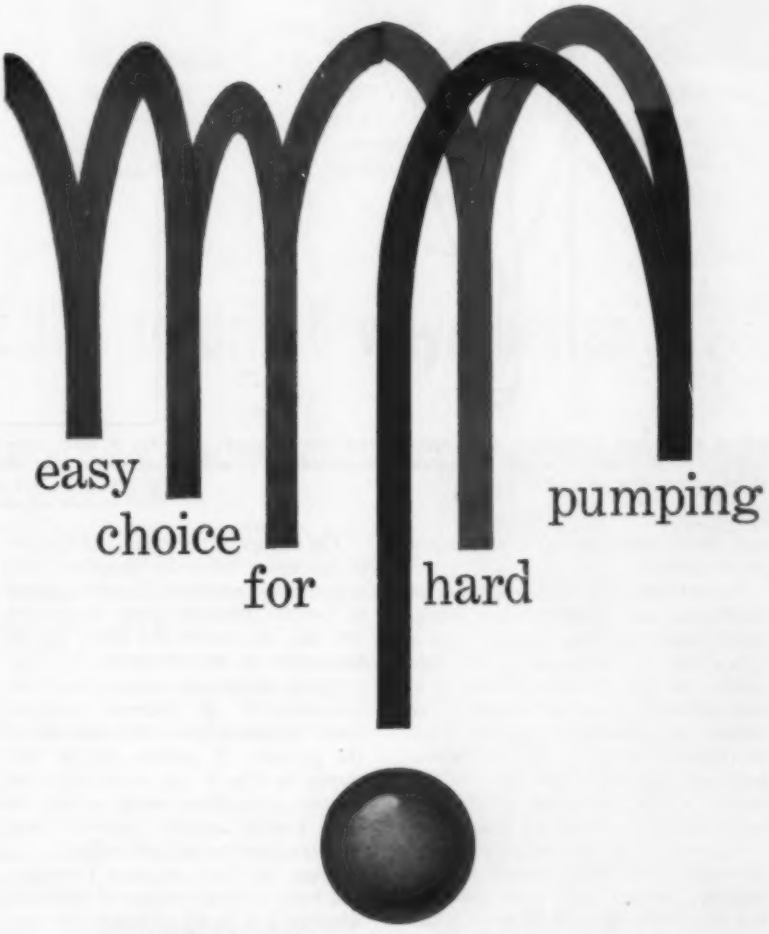
In addition to the guard resistivity, the SP is recorded simultaneously for lithology and for determination of the Rmf/Rw ratio.

Induction tool. Diagram of the induction tool, Fig. 3, shows only the main coils — one transmitter and one receiver. The alternating magnetic field induced by the main transmitter coil sets up an alternating current flow in the formation circularly around the well bore — the amount of the current flow depending upon the conductivity of the formation.

The secondary magnetic field set up by this alternating current flow in the formation is measured by the main receiver coil. The volume indicated by the dashed lines in Fig. 3 is a major zone of influence on the tool response.

As shown, this volume is flattened vertically with a reduced effect on the well bore and the invaded zone. This is accomplished by auxiliary coils which essentially focus the induced current flow. From these principles it can be seen that the tool, as a general rule, tends to be relatively more effected by the low resistivity (high conductivity) within the zone of influence. In addition to the conductivity curve, which is also recorded as resistivity, an SP

Hard pumping, or corrosive or abrasive fluids, often result in frequent, expensive pulling jobs due to valve failures. If you are having this problem, the solution lies in genuine DuMore Balls and Seats. DuMore, a special composition of chromium, cobalt, and tungsten, will take any kind of punishment because of its exceptional resistance to impact and pressure. Every DuMore Ball and Seat is manufactured to exact A.P.I. specifications. Each ball is precision ground to a sphericity of .0001". Each seat is individually ground and mated to its ball, vacuum tested, and individually packaged to assure perfectly-matched sets. Ask your supply store about DuMore. They'll tell you it's the best ball and seat you can run.



DuMore® BALLS AND SEATS

"Best Balls and Seats in the Oil Patch"

MADE BY HARBISON-FISCHER · FORT WORTH

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

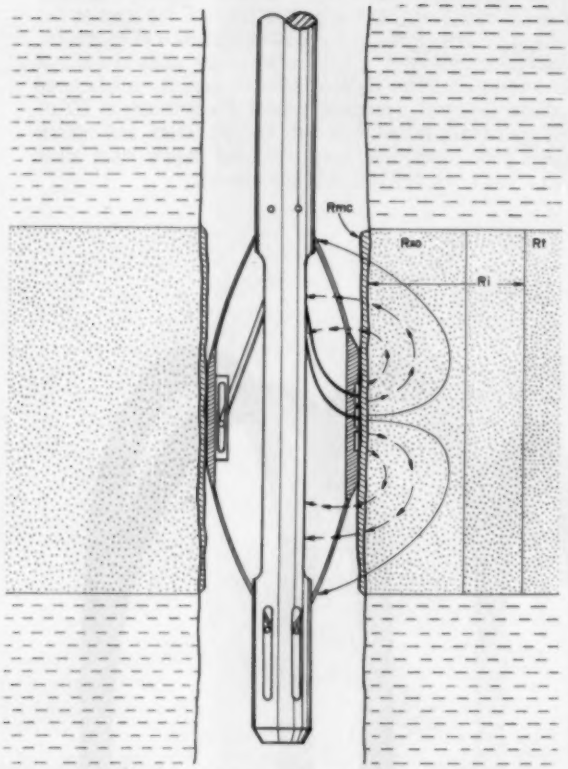


FIG. 4. FoRxo tool is miniature guard tool. Current from electrode held against bore wall is forced to flow outward as narrow beam by an encircling guarding electrode.

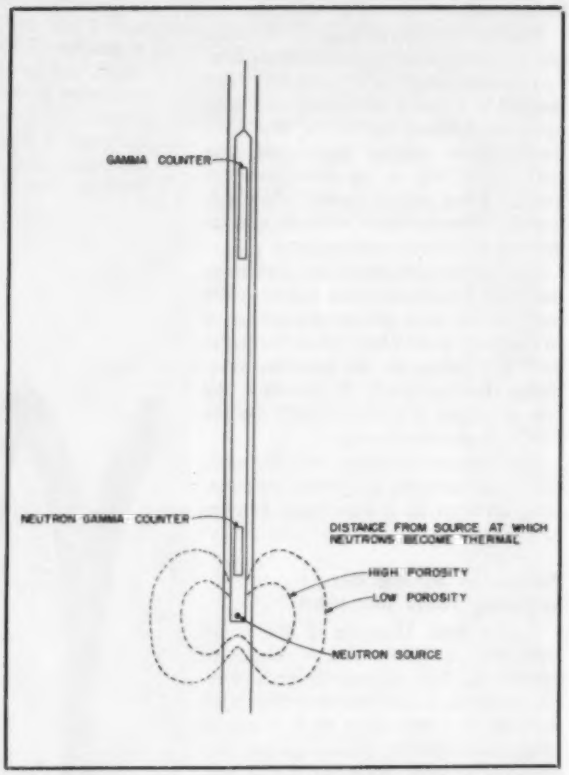


FIG. 5. When using the neutron curve to determine porosity, hydrogen atoms are most effective in slowing neutrons to thermal speed, then several atoms may capture them. Counters placed at specific distance from sources are used to record effect of formation on neutron.

and 18-in. short normal are recorded simultaneously.

FoRxo tool. Fig. 4 is a diagram of the FoRxo tool showing it is a miniature guard tool. The current from a 1-in. thick electrode on a pad held against the bore hole wall is forced to flow outward as a narrow beam by an encircling guarding electrode. Since the dimensions are small, the current path spreads out within the first few inches of the formation so that the measurement is essentially Rxo.

Since mud cake resistivity is considerably lower than invaded zone resistivity, normal mud cake thickness has negligible effect with such a pad and guarding arrangement. The vertical discrimination is such that very thin shale and hard streaks are clearly defined. A caliper curve is also recorded simultaneously.

Radioactivity tool. The usage of the neutron curve for porosity is based upon the fact that the hydrogen atoms are by far the most effective element in the slowing of neutrons to what is called thermal speed. At thermal speeds several atoms may capture these slow neutrons (hydrogen and chlorine have the highest possibility of capture) at which time a gamma of capture is emitted.

The energy of the gamma of capture is dependent upon the element which captures the neutron. Counters placed at specific distances from the source are used to record the effect of the formation on the neutrons.

Neutron-neutron counters record the concentration of thermal neutrons while neutron-gamma counters record the gammas of capture. In the tool shown in Fig. 5, the neutron-gamma counter is in effect tuned so that the high energy capture gammas from chlorine have a negligible effect.

Since the high porosity formation will have a large amount of hydrogen whether it is in oil or water, the neutrons will be slowed to thermal speeds at a short distance from the source as shown in the figure. Under such a condition, relatively few of the gammas of capture will penetrate to the counter to be recorded.

However, in low porosity formations less hydrogen is present, so that the neutrons become thermal at a greater distance from the source which is nearer the counter, as shown. Under that condition, more of the gammas of capture will penetrate to the counter and be recorded.

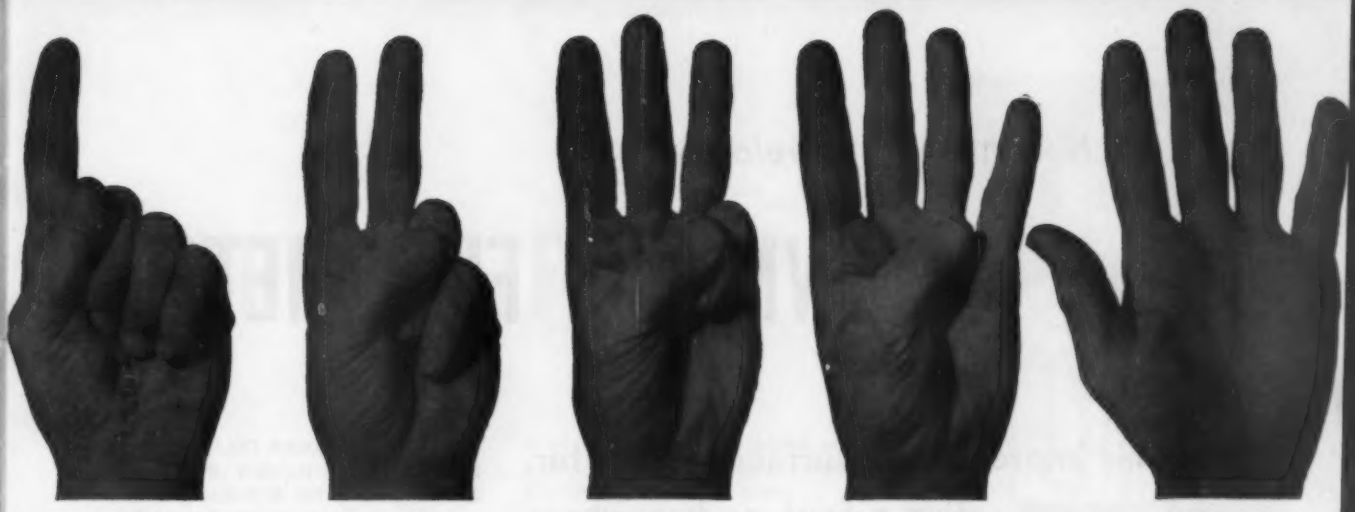
In addition to the neutron-gamma curve, the natural radioactivity of the formations is recorded by another counter at a sufficient distance from the neutron source so that there is no effect of the gammas from it. The radioactive element content of the various formations will vary widely, but clean limes, dolomites and sands have a very low radioactivity, while shales show a high radioactivity.

As a result, the natural gamma curve gives good lithological definition and can be used where the Rmf/Rw ratio is too low to give a definitive SP or in oil-base muds and air or gas drilled holes.

Since radioactive emission is a random occurrence, time constants are used to level out the readings and give a true sampling of the radioactive content. As a result, bed boundaries have a generally upthrown appearance which is exaggerated at higher logging speeds.

However, the boundaries can be determined with accuracy by picking the beginning of the deflection for the bed whose boundaries are desired.

In following issues, Part 2 of this article will elaborate on applications of guard, induction and FoRxo logging tools in particular formations and why they are suitable; and Part 3 will discuss applications of the radioactive logging device in radiation induction and guard logging.



BETTER drilling rates in all types of muds: T-8, lime, gyp, and low pH, with varying amounts of oil.

BETTER (lower) barite requirements when substituted for oil in muds.

BETTER hole lubrication, in all types of muds, to reduce pipe sticking.

BETTER bit bearing life **even in high solids muds.**

BETTER geological interpretation and electrical logs; no fluorescence.

PLAN WITH BIT LUBE to drill 5 ways better . . .

MAGCOBAR PLANNED MUD PROGRAMS make the above statements facts, not claims. In high weight emulsion muds, for example, the Magcobar engineer properly substitutes Bit Lube® for some of the oil to cut drilling costs by reducing the amount of barite required. In a typical well, the oil content of the mud was allowed to drop from 11 to 5 per cent. Bit Lube was added to this 17.8 lb./gal. lime mud with these savings in barite:

	Sacks of barite per day	Cost of barite per day	Cost of Bit Lube per day	Cost of Oil per day	Total Cost per day
Emulsion (2 week average)	177	$409.76	$—0—	$74.03	$483.79
Bit Lube and Emulsion (3 week average)	52	120.38	122.43	8.25	251.06

NET DAILY SAVINGS WITH BIT LUBE: $232.73

Not only does Bit Lube give direct cost savings, but it also offers escape from costly pipe sticking, even in extreme directional holes. Bit Lube lowers the friction coefficient of the mud, to give over-all higher drilling mud performance. These savings can be added to those in the chart.

The skilled use of good products like Bit Lube to cut drilling costs is the heart of Magcobar Technology. Let the Magcobar engineer plan the mud program for your next well and this Technology will save for you all along the line.

Magcobar
Complete
DRILLING MUD SERVICE

DRESSER INDUSTRIES, INC.
OIL • GAS • CHEMICAL
ELECTRONIC • INDUSTRIAL

New Humble development . . .

DOWNHOLE FLOWMETER

With this improved subsurface flowmeter, you can tell within a foot or two where oil or gas is entering a well's perforations

Preparing to make a flow survey deep inside a producing well, an engineer slips flowmeter into lubricator arm at wellhead. Note pleated rubber packer on shaft.

IN A WEST TEXAS OIL FIELD a few months ago, the flow of oil from one of Humble Oil & Refining Company's producing wells fell off abruptly, and the well began to make excessive quantities of gas.

The trouble, Humble's production men knew, was caused by unwanted gas finding its way into the well bore. But where, exactly, was the gas coming in? They needed to find the answer to that question before any corrective measures could be taken.

First, the crew tried to locate the point of gas intrusion by lowering a temperature gage into the well, hoping to detect a change in temperature that would indicate where the gas was entering. When that attempt failed, they decided to try a new type of instrument — a subsurface flowmeter which Humble's Production Research Division had recently perfected after several years of development.

The flowmeter is a long, tubular instrument which looks something like a blunt-nosed, slightly overweight javelin with a rubber bladder impaled about midway of its shaft. It is designed to be lowered into a well on a wire line and to measure accurately, in intervals of a foot or two, the flow of liquids or gas at any level. In the case of the problem well, the flowmeter quickly pinpointed the spot where gas was intruding; a workover crew promptly isolated the offending perforations from the flow stream, and the well was returned to normal oil production.

Versatile Flowmeter

The incident of the West Texas problem well is but one example of the varied usefulness of Humble's improved subsurface flowmeter. In the short time since the instrument emerged from its development stage, it has proved many times to be an excellent diagnostic tool in the treatment of ailing producing wells.

But that is not its sole purpose. In fact, its developers predict that the flowmeter's most important role in the future will be in providing needed reservoir information through routine flow surveys. Reservoir engineers see the

PINPOINTS FLOW

instrument as a means of filling in some blind spots in their studies of the complex subsurface storehouses from which oil and gas are produced.

In one oil field, for example, a survey conducted with the new flowmeter confirmed existence of a condition which had only been suspected. In several of the wells where 40 or more feet of casing had been perforated, the entire production of fluid was found to be coming from a thin interval of about a foot or two. There had been no proof, prior to the flow survey, that these wells were not producing from the entire perforated interval.

Use of the flowmeter in field surveys is also helping Humble's production men verify other existing conditions which they have suspected, but had no way of proving. One flow survey, conducted on a waterflood project, confirmed their suspicions that the water being injected into the reservoir to displace oil was not doing its job efficiently because all of it was not going where it was supposed to go.

If the subsurface flowmeter can perform such valuable services, why haven't oil men had one before? Actually, the need for a reliable instrument of this type has long been recognized by oil producers, and numerous efforts have been made to develop one. At least two types have previously been put into commercial use, but neither met all of Humble's requirements. Consequently, several years ago the company's Production Research Division took on the task of developing an improved flowmeter — one that would do the job effectively.

Development of Tool

The men who worked on the project knew that they would have to devise a rugged and reliable metering device, tubular in shape and small enough in diameter to pass through 2-in. tubing. Such a tool could be lowered into a producing well without interrupting production. They knew, too, that the most difficult part of their task would be to develop a suitable packer for the instrument. It was the packer which had been the greatest source of trouble in previous flowmeters, and it was to prove the biggest headache for Humble's development team.

It took years of designing, testing, redesigning, and retesting before the research group came up with a flowmeter that met their requirements. The instrument, which went into operational service a little more than a year ago, is 5 ft long and only 1 11/16 in. in diameter. Inside that slim tube nestle a metering device, a pump, and an electric motor. Outside, snugly fitted about the shaft in a recessed section, is a rubber bladder which serves as the packer.

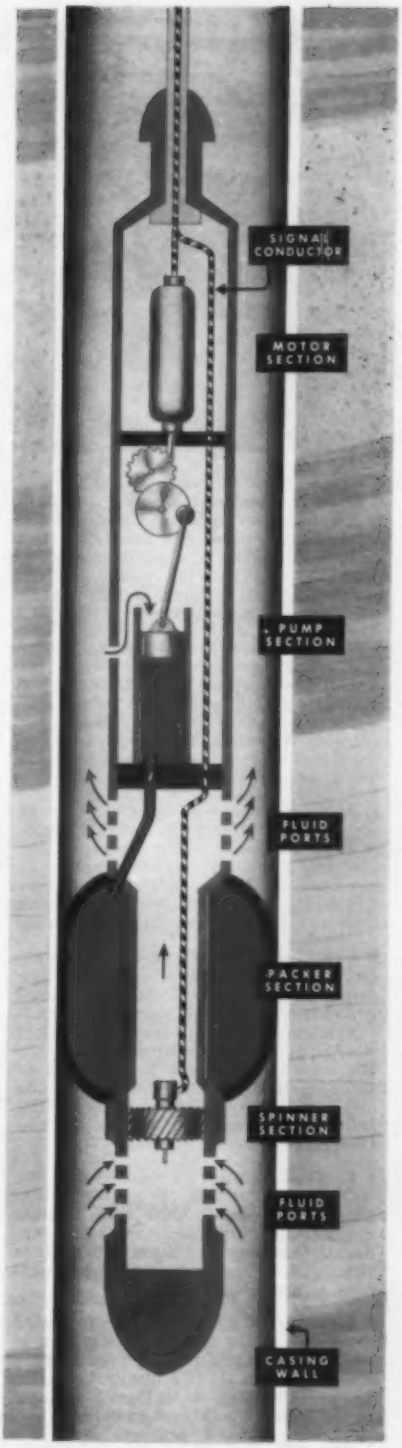
Downhole Operation

When the instrument is lowered into a well to the desired depth, the operator at the surface starts the electric motor and the pump fills the packer with fluid from the well. As the packer expands, it seals off the casing above the metering section. Any flow of fluids or gas either up or down must then pass through the meter. Electrical pulses, generated by the flow through the meter, are transmitted through the wire line to recording instruments at the surface where they are translated into usable data on the rate and direction of flow.

After a reading has been made at one depth, the operator deflates the packer by reversing the electric motor, and the flowmeter is raised or lowered to a new level. By repeating this process, a well can normally be surveyed in a matter of a few hours.

Having developed and thoroughly tested this improved flowmeter, Humble has now licensed other firms to manufacture the instruments and to provide commercial subsurface metering service for the industry. It is still too soon to evaluate fully its effect on future producing operations, but there is little doubt that the information to be gained from subsurface flow surveys can help oil men perform more efficiently their task of getting more oil out of the ground at less cost. ★ ★ ★

Reprinted with permission from *The Humble Way*, January-February 1960.



Schematic illustration of flowmeter shows the electric motor which drives the pump to expand the packer. Vaned meter section in lower end of tool measures quantity of oil or gas passing through the spinner section in either direction.

RUNNING TOUR with MEN in the INDUSTRY

George Abadjian has recently been appointed by MacPherson-Ridgeway Petroleum Equipment Company, Beirut, Lebanon, as their technical sales representative in Tripoli, Libya. Abadjian is a petroleum engineer graduate of the University of Texas.

George Abadjian

F. A. Garb

H. J. Gruy and Associates, Inc., Dallas-based petroleum engineering and geological consulting firm, has announced the election of **Forrest A. Garb** to vice president and director. He was formerly associated with Magnolia Petroleum Company and Socony Mobil.

R. F. Higginbotham, assistant division production superintendent for Sinclair Oil & Gas Company at Midland, Texas, has been transferred to Houston to serve in the same capacity in that division. He succeeds **William A. Walther Jr.,** who was appointed to a similar post with Sinclair's Tulsa division.

Announcement was recently made of the election of **George A. Peterkin,** chairman of the board of the Houston Contracting Company, to the board of directors of Falcon Seaboard Drilling Company, Tulsa. This is one of several high posts Peterkin holds in the Southwest.

Gen. Ernest O. Thompson, presently chairman of the Texas Railroad Commission, was renamed chairman of the legal committee of the Interstate Oil Compact Commission by Gov. George Docking of Kansas, commission chairman. Thompson has served three times as chairman of the Interstate Oil Compact Commission and was instrumental in drafting "The Interstate Compact to Conserve Oil and Gas" in 1935.

Clyde J. Gurley, previously with the British-American Oil Producing Company, has assumed duties as production engineer for Northern Natural Gas Producing Company in Omaha. Gurley is in charge of drilling and production operations in northeastern Ohio.

George B. Higgins Jr. has been named supervisor of the lease records section of the exploration department of Sunray Mid-Continent Oil Company. Higgins succeeds the late J. B. McDaniel, manager of the lease records department.

The new manager of the land department, Associated Oil & Gas Company, Houston, Texas, is **Robert S. Burke.** The company has oil and gas properties, processing plants and pipelines in the Texas Gulf Coast area.

Arch Clark, division civil engineer for Sun Oil Company's Southwest production division, has retired after nearly 40 years with the company. Succeeding him is **Kirby Hillin,** assistant division civil engineer since 1959.

Albert Benjamin has been named director of public relations for Texaco Inc., succeeding **Thomas D. Durrance,** who has been appointed manager of public relations for Texaco's affiliate, Arabian American Oil Company. Previously Benjamin was manager of the department's Latin American Division at Caracas, Venezuela.

B. L. Francis has been appointed staff petroleum engineer of the Domestic Producing Department of Texaco Inc. in New York.

Wayne E. Glenn, general manager, production, Continental Oil Company of Houston, Texas, is the newly installed president of the Society of Petroleum Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers. At the recent national convention in New York, President Glenn predicted that the present oversupply of crude oil will be erased by the world's increasing desire for more oil.

The top position in the world's largest geological organization is now held by **Dr. Ben H. Parker,** president of the Colorado School of Mines board of trustees. He has been elected president of the American Association of Petroleum Geologists and is also vice president and director of the Frontier Refining Company, Denver.

The National Association of Corrosion Engineers has elected new officers for the year begining March 1960. **George E. Best,** Manufacturing Chemists' Association, Washington, D. C., is president; **Edward C. Greco,** senior research chemist, United Gas Corporation, Shreveport, Louisiana, is vice president; and **C. G. Gribble Jr.,** district manager for Metal Goods Corporation, Houston, Texas, is treasurer.

Thracy Petrides has been appointed director of government programs of U. S. Industries, Inc. For the past two years Petrides has been head of USI's Military Systems Planning Group.

Thracy Petrides

A. M. Cuellar

Adolph M. Cuellar has been appointed manager of the newly opened Houston sales office of The Happy Company.

At the annual meeting of the Canadian Petroleum Association held recently in Calgary, the 1960 board of governors was elected. The newly-elected governors then chose **A. O. Detmar** of Mobil Oil of Canada, Ltd. as chairman; **J. S. Black** of South Saskatchewan Pipe Line Company, first vice-chairman; and **E. J. Gallagher** of The British American Oil Company Ltd., second vice-chairman.

Effective March 1, **B. L. Francis** became staff petroleum engineer of the domestic producing department of Texaco Inc. in New York. Previously he was petroleum engineer in the general manager's office, Houston.

Paschal Martin, petroleum engineer, has been employed by the Ebro Oil Company, Inc. of Longview, Texas, as chief engineer.

Kenneth R. Joynt of Houston has been elected a director of Mobil Oil of Canada, Ltd., and was named a vice president and manager of producing for the Calgary-based affiliate of Mobil. Previously he was operations superintendent for the Houston Exploration and Producing Division of Mobil Oil.

H. S. McQueen

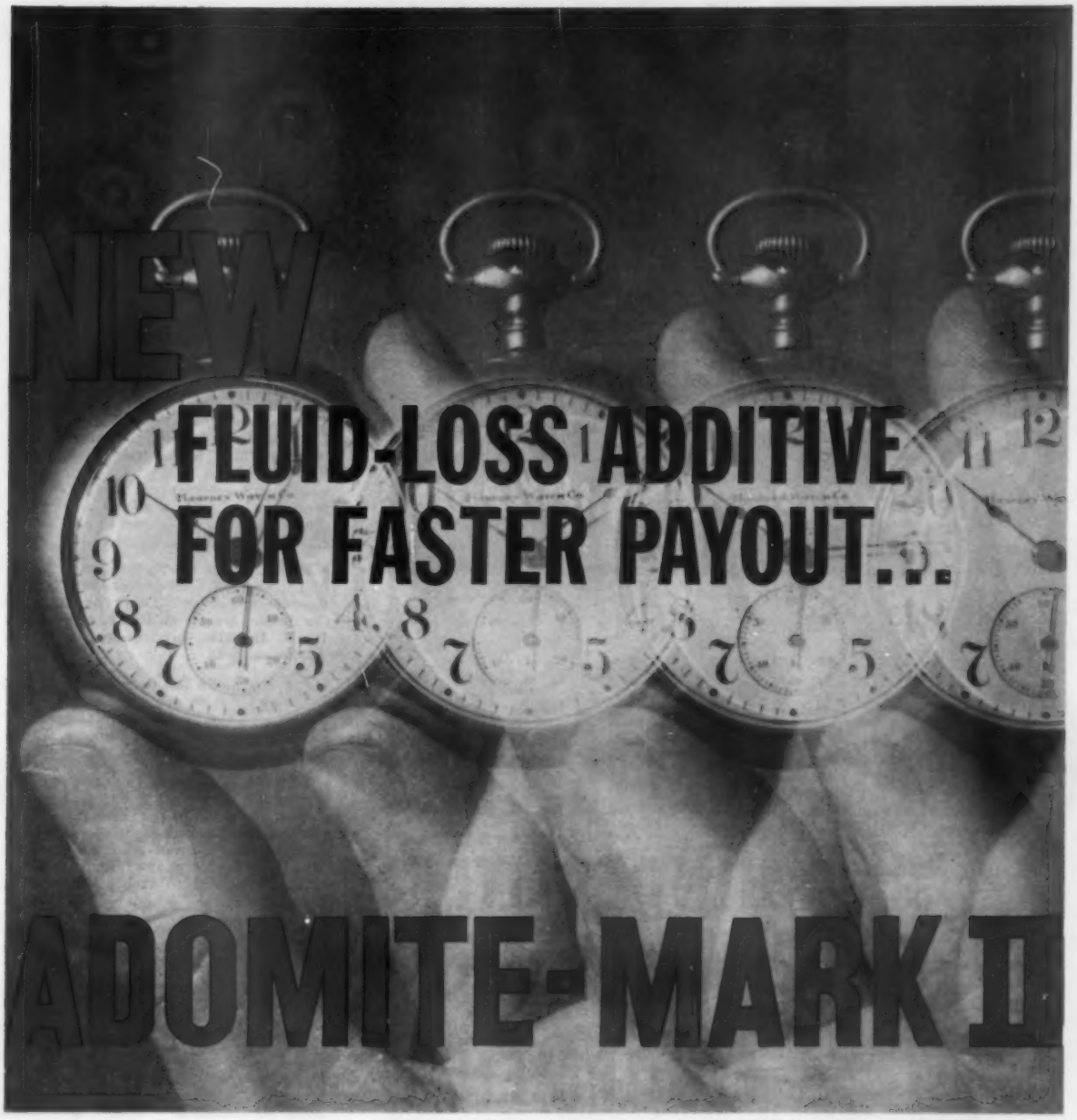
Henry S. McQueen, executive vice president, chief geologist and director of the Salt Dome Production Company, has resigned to become a consulting geologist. McQueen will continue to serve Salt Dome in the capacity of a consultant.

About June 1 personnel changes in the Pure Oil Company's exploration and production division will be effected. **Stewart Cronin,** exploration manager, will transfer to Calgary, Alberta, to take charge of Pure's activities in Canada and Alaska. **Karl A. Mygdal,** geological representative in Calgary, will transfer to the company's new Northern producing division headquarters in Denver. **Fred A. Devin** of the Rocky Mountain producing division will transfer to Chicago as exploration manager. Assisting him will be **John H. Maher** as chief stratigrapher and **J. Lee Davis** as chief geophysicist.

Chester M. Harden, drilling and production superintendent for the Pure-Signal-Sohio group in Venezuela, will become manager of production with headquarters in Chicago. **James R. McChesney** will remain as manager of the gas department and **Floyd L. Stewart** as chief production engineer. **Raymond H. Rantala** of the geological staff will become manager of exploitation with responsibility for evaluation studies of production and reserves.

Robert W. Geehan of Denver, Colorado, has been named regional director of Region III of the Bureau of Mines, Department of the Interior, with headquarters in Denver. **J. H. East, Jr.,** the previous regional director and holder of the Department's Distinguished Service Award, recently retired.

H. E. Lumpkin has been promoted to senior research chemist and **H. E. von Rosenberg** to senior research chemical engineer in Humble Oil & Refining Company's research and development division at Baytown, Texas. Lumpkin is engaged in analytical research, specializing in the field of mass spectrometry; Dr. von Rosenberg, in research on catalytic cracking.



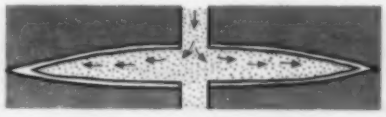
Now—from the makers of ADOMITE comes the last word in fluid-loss additives—new ADOMITE-MARK II. Regardless of the kind of fracturing oil medium you use, new ADOMITE-MARK II will give the fullest possible fluid-loss control. Result? Larger fractures and faster payouts every time!

You, along with many other producers, may want to continue to standardize on ADOMITE, proven in over 20,000 fracturing treatments to be an efficient fluid-loss control additive for a wide range of crudes.

Where unusual conditions exist and optimum fluid-loss control is imperative, ask for ADOMITE-MARK II . . . now available from your service company.

For more detailed information contact your nearest ADOMITE man:

R. T. Means, P. O. Box 431, Midland, Texas, MU 4-7411
R. W. Hughes, Oklahoma City, Okla., CEntral 2-1371
Joe M. Foster, Wichita Falls, Texas, Phone 723-8181
H. L. Thomason, Casper, Wyoming, Phone 3-3721
J. D. Hawsey, Pampa, Texas, Phone MOhawk 5-2992

ADOMITE®  *. . . fluid-loss additives*

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

▸ **A. L. Hill,** formerly manager of geological and reservoir engineering for El Paso Natural Gas Company, has been named general manager of production and exploration for the firm.

Other promotions within the department include the appointment of **Warren L. Taylor** as manager of geological and exploration operations; **A. M. Derrick,** manager of reservoir engineering, and **L. G. Truby, Jr.,** manager of production. **Samuel Smith** continues as manager of the land department.

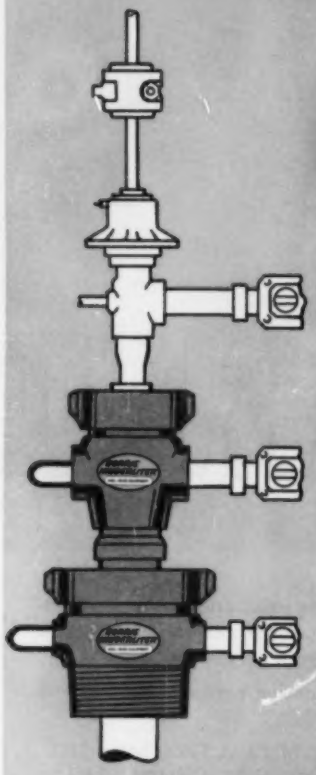
Appointed division superintendents of geological and exploration were **Robert N. Richey,** Salt Lake City, Utah; **D. N. Canfield,** Farmington, New Mexico, **A. E. Miller, Jr.,** Amarillo, Texas, and **Hal S. Dean,** Midland, Texas.

▸ Crestmont Oil Company has opened new corporate offices at 2622 Mission Street, San Marino, California. Crestmont is engaged in the exploration and production of crude oil and natural gas in California and Texas.

▸ California Research Corporation has announced that **Ronald N. Beamer** has accepted a position as research engineer at their La Habra laboratory.

▸ **Harrison F. Murray** has been appointed to the newly created position of chief staff geologist in the production and exploration department, Lion Oil Company Division of Monsanto Chemical Company. He will be located at the department's headquarters in Houston, Texas.

Engineered Simplicity



NORRIS
HINDERLITER
WELL HEAD
EQUIPMENT

Write for Well Head Equipment Bulletin for complete information.

W. C. NORRIS, MANUFACTURER
DIVISION OF DOVER CORPORATION
P. O. BOX 1739 • TULSA, OKLAHOMA
BRANCHES: Great Bend, Kansas; Corpus Christi, Houston, Kilgore, Odessa, Wichita Falls, Texas; Oklahoma City, Oklahoma; Salem, Illinois; Casper, Wyoming; Farmington, New Mexico; Edmonton, Alberta, Canada.
NORRIS HINDERLITER WELL HEAD EQUIPMENT
Buy From Your NORRIS Distributor

▸ **H. F. Nabors,** formerly general manager of Continental Oil Company's central region, has been promoted to the newly created position of manager of production in Continental's foreign department, with headquarters in New York City. He assumes his duties after completing a 13-week advanced management course at Harvard University.

▸ Tennessee Gas and Oil Company, a division of Tennessee Gas Transmission Company, has announced new assignments for five of its exploration department personnel. **W. H. Medary,** former district exploration superintendent at Midland, Texas, has been transferred to Lafayette, Louisiana, as district superintendent for both onshore and offshore exploration operations. **Robert M. Grace** has been named as Medary's replacement at Midland, where he was formerly district geologist. Other changes include: **Glenn Dille,** promoted from geologist to district geologist at Oklahoma City; **E. M. Christensen,** landman, transferred from Wichita Falls, Texas, to Lafayette; and **R. F. McMillen** of Denver, formerly division unit representative in the Rocky Mountain division, transferred to Houston as unitization supervisor in the exploration properties section.

▸ **Roy A. Payne** has been named manager of The Gulf Oil Corporation New Orleans Production District. Other managers in the district are **H. D. Ritter,** exploration; **W. B. Hopkins,** production; and **J. A. Austin,** services.

▸ **J. S. Detweiler** has been appointed Oils Planning Division manager for the manufacturing department of Standard Oil Company of California, Western Operations, Inc.

▸ **Harold C. Teasdel,** president of The California Company since 1947, has been elected chairman of the company's board of directors. **Kenneth H. Shaffer,** formerly chairman of the board of directors of the Standard Oil Company of Texas in Houston, was elected to succeed Teasdel as president.

H. C. Teasdel

C. F. Whaley

▸ **C. F. "Chet" Whaley** became vice president of Columbia Drilling Company, Houston, on May 1. Columbia Drilling Company operates rotary drilling rigs in the Gulf Coast areas of South Louisiana and Texas.

▸ **Noel D. Morris** has been named manager of the new Well Drilling Machinery Division at Alten Foundry and Machine Works, Inc., Lancaster, Ohio. Morris' appointment as manager of the division marks Alten's entry into the well drilling field. Having acquired the design, engineering and manufacturing patents of the Loomis Machine Company, Alten is manufacturing and marketing an improved model of the Loomis rig in two sizes, 24 and 32. Known as the Alten-Loomis Super Clippers, these rigs can now be purchased through an increasing number of Alten dealers.

and each heat of steel used in making Liberty Sucker Rods is normalized at a "tailored" temperature.

The normalizing temperature vitally affects the physical properties of sucker rods. It is so important that, at Liberty, each heat of steel is carefully tested and analyzed so that the one exact normalizing temperature can be predetermined to assure the maximum desirable physical properties.

Unless this "tailored" normalizing temperature is determined exactly, variation in the physical properties of sucker rods of the same type is possible. This, in turn, could mean that rods in the same production string would have different performance characteristics, and, as every producer knows, a rod string is only as strong as its weakest rod.

That is why Liberty spares no expense or effort to assure that every Liberty Sucker Rod of the same type and size performs exactly as specified. For at Liberty, the goal is not to produce the most sucker rods in the least time, but to produce the finest sucker rods — regardless of time!

FOR EXCELLENT PRODUCTS AND SERVICE
SPECIFY LIBERTY SUCKER RODS AND PUMPING UNITS

• SOLD ONLY THROUGH SUPPLY STORES •

LIBERTY

MANUFACTURING COMPANY OF TEXAS

4025 Hemphill Street • Fort Worth, Texas

LM-7

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

3 new HUGHES ROCK BITS

cut hole time in hardest digging

Footage and penetration rate are being substantially increased with the three new Hugheset bits, pictured on the adjoining page. They are expanding the range of formations that can be advantageously drilled by R Series bits. The three new Hugheset bits have been designed to drill specific segments of hard formations. All three are fortified on the gage surfaces with sintered tungsten carbide compacts to minimize wear and assure full gage hole.

1 RG-7J is designed to drill the weaker or softer segment of hard formations (lime, dolomite and hard sandy shale). Design of the bit assures more action on bottom and faster penetration. Deeper intermesh, wide spacing of the compacts, and interruptions of the lands make it possible for the RG-7J to economically drill formations previously drilled by milled-cutter and R-1 bits.

2 RG-1J which replaces the R-1, R-1J and RG-1, is designed to drill the medium range of hard formations which are normally very abrasive. Because of its fortified gage, the performance of the RG-1J in these formations is outstanding.

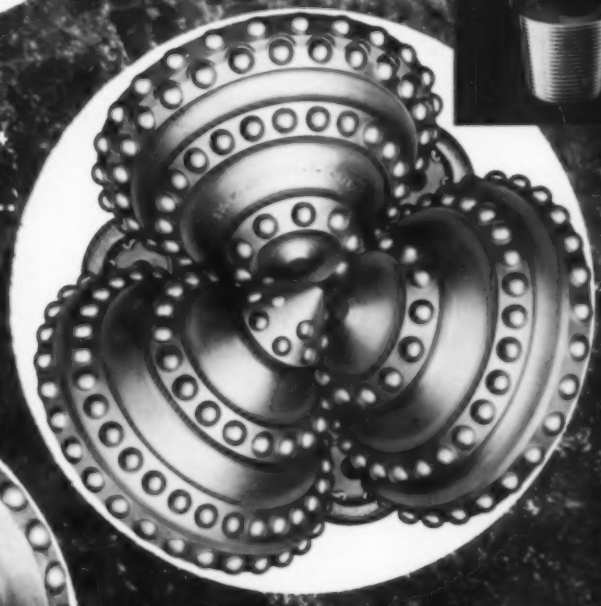
3 RG-2BJ — identified by spearpoints on each of the three cones — has larger diameter compacts and a maximum number of compacts on all rows and on the gage surfaces. It is the most rugged of the R Series bits, and is designed to drill the hardest of the hard abrasive formations, such as quartzite and hard quartzitic sands.

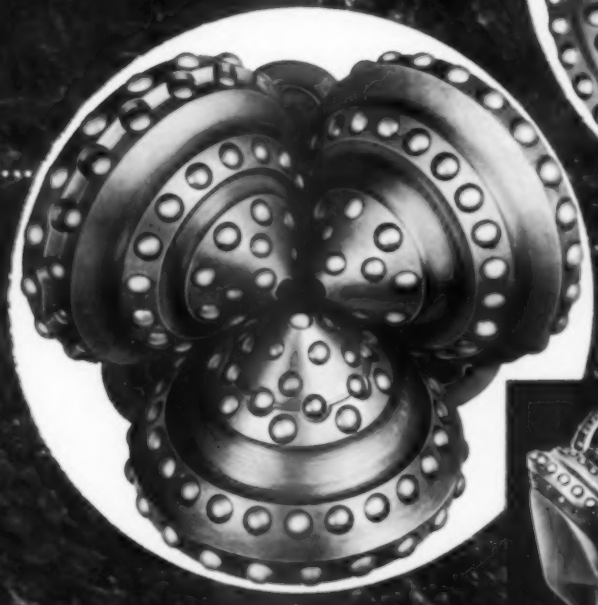
HUGHES TOOL COMPANY

ORIGINATOR AND WORLD'S LEADING DEVELOPER OF CONE-TYPE ROCK BITS

1. **RG-7J** . . . 8¾"

2. **RG-1J** . . . 6" - 9"



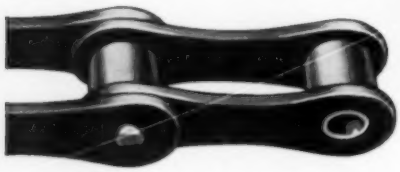


3. **RG-2BJ** . . . 8¾", 9", 9⅞"

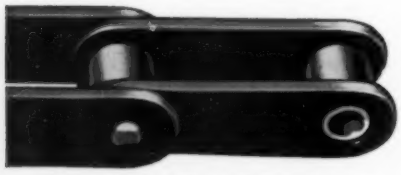
SINGLE STRAND

DOUBLE STRAND

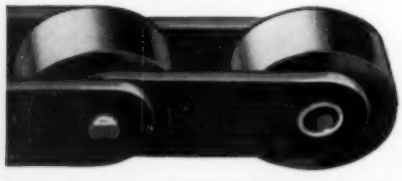
SINGLE STRAND, HEAVY SERIES



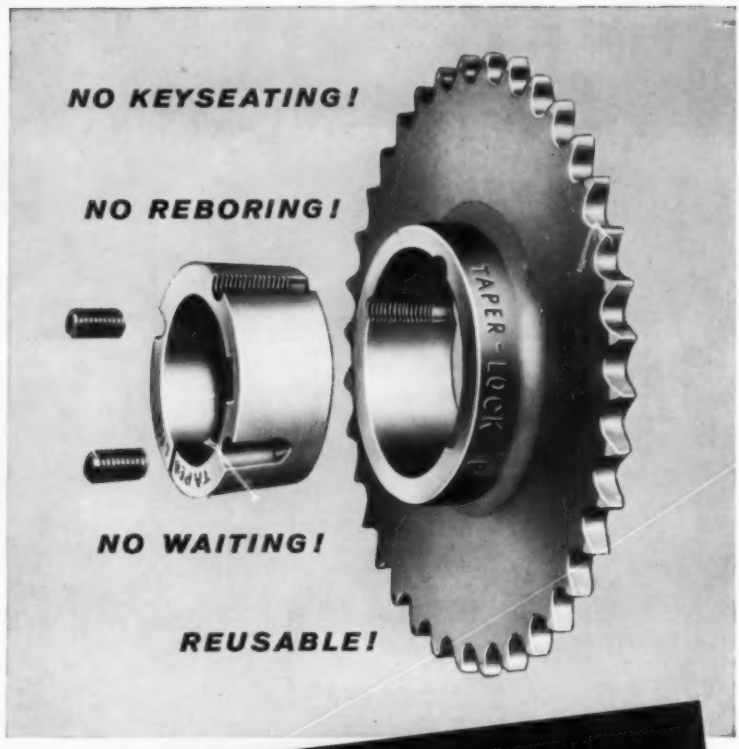
DOUBLE PITCH TRANSMISSION



DOUBLE PITCH CONVEYOR



DOUBLE PITCH CONVEYOR, LARGE ROLLERS



TAPER-LOCK SPROCKETS DODGE ROLLER CHAIN

DODGE Quality Roller Chain, teamed with Dodge Taper-Lock Sprockets, results in chain drives and chain conveyors that have the precision, efficiency and stamina necessary for the real economy of *long life*.

Moreover, Taper-Lock's reusable bushing makes a difference in overall cost. The ease of Taper-Lock mounting, the elimination of reboring, keyseating, and wasted time, add to the saving. Precision machining and true articulation lengthen the life of *both* sprocket and chain.

The Dodge line of chain, including standard attachments, is extensive. It meets a high percentage of all chain requirements.

In the Double Pitch series (both Transmission and Conveyor) the sizes which require special spacing for perfect tooth action are offered from stock in special double pitch design — to double the life of the chain and the sprocket!

Ask your local Dodge Distributor. Or write us for bulletin.

DODGE MANUFACTURING CORPORATION, 7900 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

DODGE
of Mishawaka, Ind.

EXPERIENCED HANDS...

at your service
from
WILSON SUPPLY

The Wilson supply man who makes your rig or field location is an experienced supply and equipment man. He's there to be of service to you. He'll see to it . . . You get what you want . . . When you want it.

"WHAT YOU WANT – WHEN YOU WANT IT"

WILSON SUPPLY CO
HOUSTON, TEXAS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

It's New

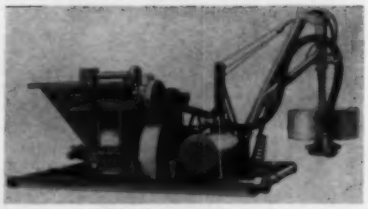
Drilling - Producing Equipment

Mud Pump Has Automatic Feed and Mixer

Automatic feed and mixer on Thompson mud pump recently developed is designed to closely control dry muds and chemicals, except caustic soda, mixed in the mud system.

The pump delivers mud to the system thoroughly mixed, and the manufacturer states that field tests indicate that it has provided an increase in gel yield of 15 to 30 percent over mud mixed by the usual method of hand-feed and jet mixing.

Mud system can be set up and mixed



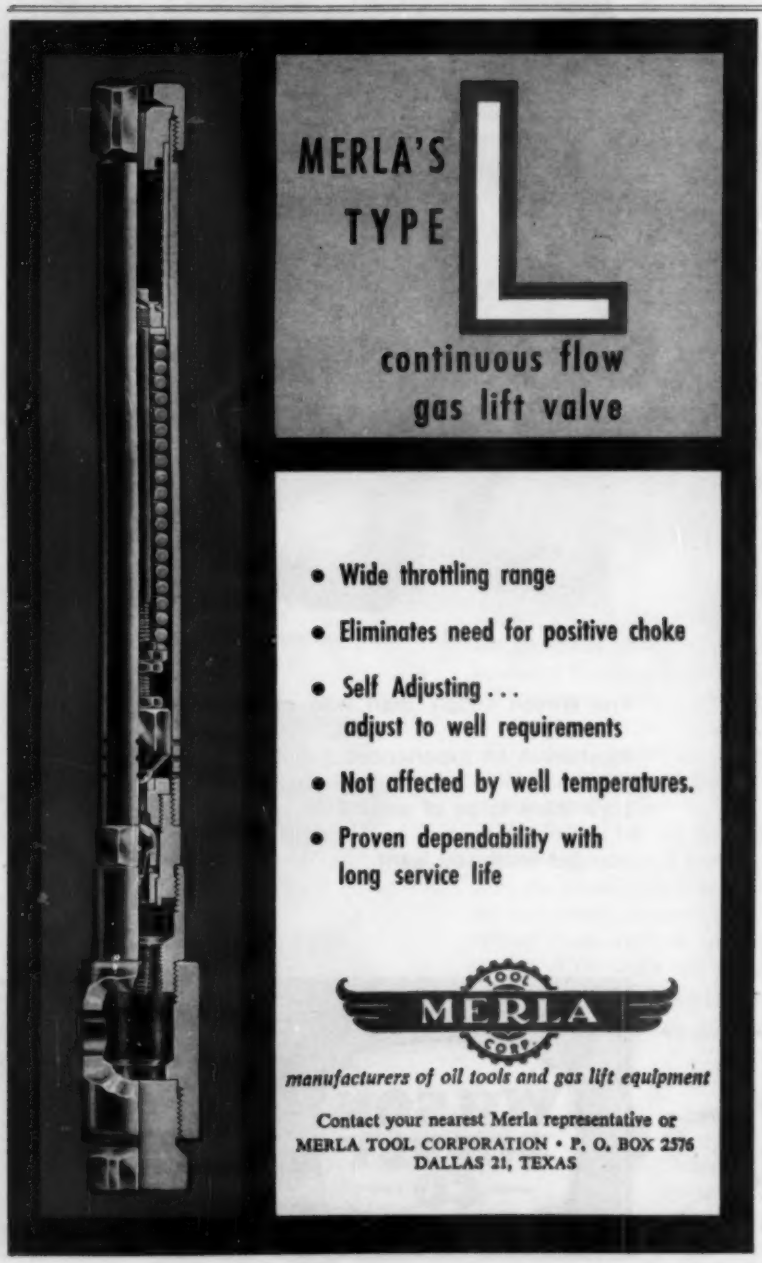
while completing rigup of other equipment, and it can be kept on hand until needed.

The mud and chemical mixer requires no additional pump or outside power, as it is a complete unit. When the hopper is filled and correct feed set, it requires no further attention until it is empty.

Pump design allows obstructing particles to pass, and it is self-sealing without a diaphragm. Since there are no high-pressure jets in the mixer, they cannot cause abrasive cutting action.

Unit's specifications include length, 11 ft 6 in.; height, 6 ft 7 in.; width, 6 ft 4 in.; horsepower required, 36 bhp at 1500 rpm; hopper volume 500 lb bentonite, 1000 lb barites; hopper feed rate, 100 to 3500 lb per hour; and pump volume, 250 gpm. *Thompson Tool Company.*

Circle number (1) on reply card.



Flowline Wrapping

Fiberglas Outer Wrap for the protection of underground pipelines has been announced by Owen-Corning Fiberglas.

Bitumen-saturated fiberglas is resistant to impact and soil stress; and it is not affected by acids and fungus.

Characteristics are that it will not stretch unduly, shrink, sag, or rot underground. It will not absorb soil moisture and is immune to soil acids and electrolytic action. Fiberglas will not attack the pipe or wick-out the oils of saturants. *Owens-Corning Fiberglas Corporation.*

Circle number (2) on reply card.

Multiple Completion Joint Protector

Grigsby Blast Joint Protector is a lightweight, high-temperature, high-impact plastic, protective sleeving for steel tubing strings in multiple-completion oil and gas wells. It protects from blasting damage during casing perforations.

Protector is fitted to the exterior walls of steel tubing through a processing method. It is designed to resist shifting, sliding, buckling, or bellying under pressure.

Coating is compounded to offer protection at temperatures up to 285 F and pressures up to 12,000 psi.

Protector resists abrasive action under high temperatures, and effects of normal acids and alkalies. It is sufficiently flexible to take the normal deflections of the piping. *Grigsby Brothers, Inc.*

Circle number (3) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Filling in the Gaps . . .

Web Wilson Tools Added to Baash-Ross Line

With the addition of the famous Web Wilson tools, our customers will gain the advantage of better service in dealing with just one manufacturer for even a greater part of their drilling equipment.

The Web Wilson hooks, elevators and links, tongs, and other products can now be ordered together with all other Baash-Ross equipment through supply stores everywhere.

Specify with confidence Baash-Ross—Web Wilson tools . . . your assurance of even better service from quality tools.

OUR 41ST YEAR OF PROGRESS

BAASH-ROSS JOY

EXTENSIVE RENTAL AND SERVICE FACILITIES ARE AVAILABLE IN MOST OIL FIELD AREAS . . . CALL US.

BAASH-ROSS

DIVISION OF JOY MANUFACTURING COMPANY

General Offices: Houston, Texas

NOW—

INCLUDE ACID IN YOUR

PERFORATING

WITH WESTERN'S STINGER PERFORATOR

VELOCITY PERFORATING WITH AN ACID STINGER and the RETRIEVABLE STRIP CARRIER

Have YOU Tried It Yet?

CALL YOUR WESTERN ENGINEER

THE WESTERN COMPANY

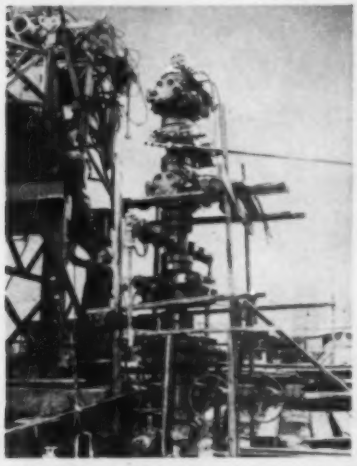
General Offices: P. O. Box 186, Fort Worth, Texas

Service Districts Throughout The Southwest

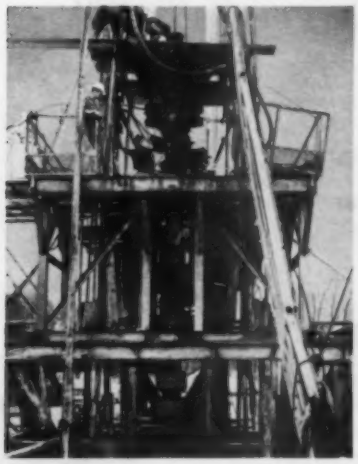
WESTERN *Engineered* WELL SERVICES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Cameron controls safeguarded this tricky re-work operation — sanding was encountered at 13,500 ft. and the production string had to be pulled. A surface pressure of 8,700 psi was safely held in check.



This stack of Cameron preventers helped regain control after a blowout occurred while coming out of the hole.



This well caught fire, after a casing failure, fortunately bridged and extinguished itself — once again under control it required extensive re-work before drilling could continue.

WILL WE ALWAYS HAVE WILD WELLS?

As long as there are high pressures to be handled there will be potential hazards. But there is constant progress to make drilling in pressure zones a safer, more economical operation.

Cameron Drilling Controls have a two-fold purpose. First to give the most reliable protection while making hole — and second to regain control if disaster strikes.

To your left are three recent cases in which lost control was regained or maintained while re-working, because the operators knew they could Count on Cameron during this demanding procedure.

Cameron

IRON WORKS, INC.

P. O. Box 1212 — Houston, Texas

Export Office: 7912 Empire State Bldg., New York City. In England: Cameron Iron Works Ltd., 76 Grosvenor St., London W. 1 England

Handy engineering aids to help you select the right equipment

Pumping units, sucker rod strings, prime movers—all major equipment for a producing well can be selected quickly and correctly with one or more of Bethlehem's free engineering aids. Each has been designed with the same careful attention to accuracy as the Bethlehem production equipment itself.

To obtain your aids, phone or write the nearest Bethlehem office or store—or simply attach the coupon to a post card.

BETHLEHEM STEEL COMPANY, Supply Division

General Offices and Export Dept.
21 East Second St., Tulsa, Okla.

Canadian Distributor:
Bethlehem Supply Company of Canada, Ltd.
Calgary, Alberta, Canada

TO: BETHLEHEM STEEL COMPANY, SUPPLY DIVISION
SALES DEPARTMENT PE, BOX 2171, TULSA 2, OKLAHOMA

Please send me:

- ☐ Booklet 1646, Bethlehem Pumping Units
- ☐ Booklet F, Simplified Selection Charts
- ☐ Handbook 489, Sucker Rod Handbook
- ☐ Calculator 1621, Bethlehem Production Estimator

NAME:_____

TITLE:_____

COMPANY:_____

ADDRESS:_____

CITY & STATE:_____

BETHLEHEM STEEL
SUPPLY DIVISION

Jet Perforators

The McCullough Mac-Jet Perforator is an expendable, small diameter jet perforator designed to obtain production from thru-tubing and slim hole completion.

Features are an enclosed firing system, minimum debris, and uniform perforation characteristics regarding size, length, and shot density.

Firing system on each unit is self-contained. This includes the set charge and an integrated firing system, enclosed in a frangible, high strength, acid resistant case. When fired, entire perforator shatters into very small pieces which will fall to the bottom of the well and not obstruct subsequent operations in the perforated zone.

Gun is designed to give uniform, large perforations, and it is available in 1 11/16 in. and 2 1/16 in. OD sizes. Standard shot density is 4 per ft at 90 deg phasing. Disintegrating spacers are supplied to provide fewer than 4 shots per ft or to blank-off sections when required. *McCullough Tool Company.*

Circle number (4) on reply card.

Pumpable Bridging Agent

Pumpable bridging agent in the form of wedge-shaped plugs is available for sealing really large fractures. Masterplug is being used in serious lost circulation conditions.

The bridging agent should be used with a lost circulation sealer. It mixes readily and pumps easily through standard mud pumps and is reasonably priced. Shape of the plug allows each plug to jam against the adjacent plugs. *Masterseal Company.*

Circle number (5) on reply card.

Pulse Code Telemetering

Vapor Recovery Systems will furnish, upon request, a new Pulse Code Telemetering System Bulletin CP 3707.

It describes and illustrates several applications of the Pulse Code Telemetering System for the remote indication of liquid level; temperature; PD meters; pressure gages; control device indicators; data gathering and reduction; alarm and control functions. *Vapor Recovery Systems Company.*

Circle number (6) on reply card.

Electrical Logging

A 14-pen field recorder keeps the currently-logged section of the actual record in plain view all the way from total depth to the casing seat.

Birdwell recorder combines the strip chart and galvanometer recording to give a complete linear record in 2 depth scales that is reproducible without drafting. *Birdwell division of Seismograph Service Corporation.*

Circle number (7) on reply card.

Subsurface Hydraulic Production Unit

Oilmaster, a subsurface hydraulic production unit, is being marketed in a variety of sizes and engine-pump combinations. It is used with power oil pump and a cleaning and storage system located at the surface. Clean crude oil, directed down the well at relatively high pressures from a triplex pump, gives reciprocating action to the subsurface hydraulic unit which pumps production oil to the surface.

Balanced design pump unit uses the same amount of high pressure oil on both the upstroke and downstroke, both strokes doing the same amount of work in displacing either spent power oil or production fluid.

Unique feature is a flood valve that prevents fluid pound, thus reducing shock loads and improving service life. Flooding also provides clean oil lubrication to the pump plunger.

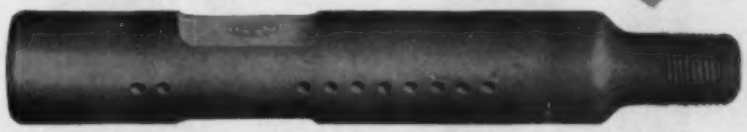
Reversing valve will switch at any point in the downstroke if sand or other obstruction causes the plunger to stick during the downstroke, and it will pull away.

Units are available for use in the nominal 2-in., 2½ in., and 3 in. (API 2⅜ in., 2⅞ in., and 3½ in. tubing). *Fluid Packed Pump Company, division of The National Supply Company.*

Circle number (8) on reply card

Only **SPANG** can give you the best in *Strength, Service, Economy and Footage* in a Prosser-type

SWIVEL ROPE SOCKET



There are times when an ordinary rope socket will meet your needs. But there are too many times when you can't afford to risk trouble—when you require a rope socket that's precision made and utterly dependable under all conditions. This is the time you'll be glad to have a Spang Rope Socket on the business end of your string—

. . . AND HERE'S WHY SPANG'S BEST

- Completely Heat-Treated for maximum toughness and hardness
- Precision machined
- High steel strength
- Extra strong joint
- Carefully finished inside bore
- Perfect setting for cable
- Socket neck grooved for the use of fishing tools
- Made by the country's oldest and largest manufacturer of cable tools

SPANG & COMPANY

DEPT. O-7 BUTLER, PENNSYLVANIA

For over 60 years Manufacturers of Spang Weldless Jars and a Complete Line of Cable System Drilling and Fishing Tools for Oil and Gas Wells, Water Wells, Prospect Drilling and Shot Blast Holes.

another TRETOLITE SERVICE report

More salable oil results from an adequate treating program

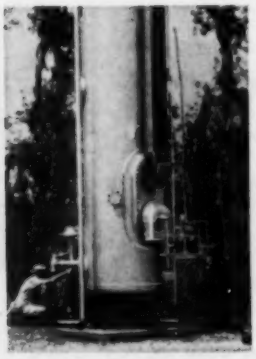
LET YOUR TRETOLITE MAN SHOW YOU HOW

Your TRETOLITE field service engineer is always on call . . . always ready to help you. He will gladly survey your treating operation for maximum efficiency.

Here are some important treating factors he will check:

1 ***Treating chemical***

Is it the best for your operation?
Your TRETOLITE engineer will make tests and make sure.



2 ***Mechanical operations***

A faulty pump, a damaged valve, and many other mechanical factors can affect the severity of emulsification. Your TRETOLITE engineer will consult with you on such possibilities.

3 ***Chemical-heat balance***

Sometimes a little more chemical or a more efficient chemical can be used to reduce heating. The use of less heat can cut vapor losses which reduce gravity. Often a few degrees gain in gravity can earn a better selling price. Your TRETOLITE engineer will be glad to check this phase of your operation for you.

4 ***Chemical pump-chemical reservoir.*** Chemical pump malfunction or improper chemical pump location can cause trouble; so can a dirty chemical supply tank. Your TRETOLITE field service engineer will go over your chemical feed procedure and equipment —carefully, knowingly.

TF-60-2

PETROLITE CORPORATION

TRETOLITE COMPANY
DIVISIONS
369 Marshall Avenue, Saint Louis 19, Missouri
5015 Telegraph Road, Los Angeles 22, California

CANADA: Petrolite Corporation of Canada, Limited, Edmonton, Alberta
ENGLAND: Petrolite Limited, 20 Savile Row, London W.1
VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

REPRESENTATIVES
BRAZIL: WERCO, Ltda., Avenida Rio Branco 57-s/1410-11, Rio de Janeiro
COLOMBIA: W. F. Faulkner, Calle 19, No. 7-30, Office 807, Bogota
GERMANY: H. Costenoble, Guiollettstrasse 47, Frankfort, a.M.
ITALY: NYMCO S.p.A. 9, Lungotevere A. da Brescia, Rome
JAPAN: Maruwa Bussan KK, No. 3, 2-Chome, Kyobashi, Chuo-Ku, Tokyo
KUWAIT: F. N. Dahdah, Box 1713, Al Kuwait
MEXICO: R. E. Power, Sierra de Mijes, No. 125, Mexico, D. F.
NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
PERU: Oilfield Import, S. A., Apartado 71, Talara
TRINIDAD: Neal and Massy, Ltd., P.O. Box 544, Port of Spain

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

THE OIL OF TOMORROW will flow through wellheads on deep ocean floors that dimly reflect the shimmer of strange marine life. As it has in many things--unitized trees, high pressure and multiple completion equipment--O-C-T is pioneering in underwater completion equipment and techniques.

Free full color print of above illustration, suitable for framing, upon your request.

where progress is a daily practice

O·C·T

OIL CENTER TOOL CO.

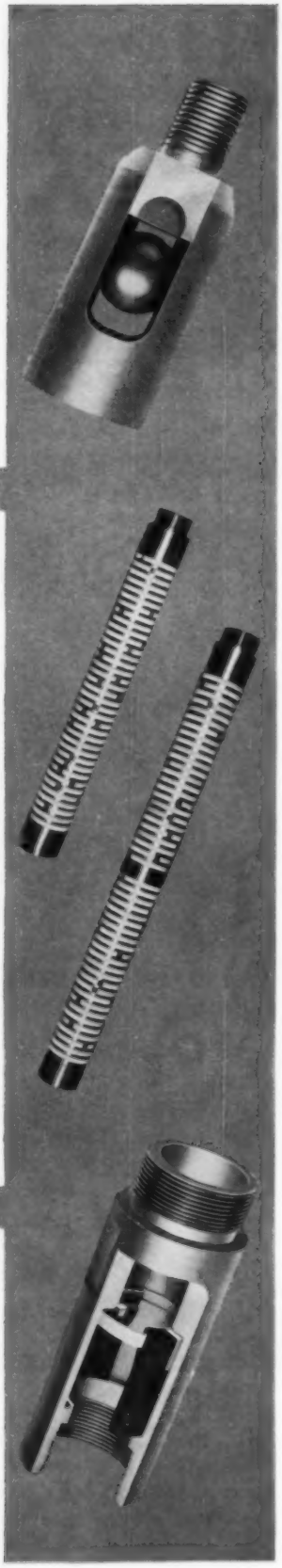
SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

Address Export Inquiries for All Countries to
P. O. Box 3091, Houston, Texas.

Let R-u-b-b-e-r Take The Wear

in your sucker rod pumps

It Costs You Less That Way



Both **MARTIN PLUNGERS** and **MARTIN RUBBER GUIDE CAGES** are the result of correct engineering to fully utilize the excellent properties of rubber.

In the **MARTIN SPLIT RINGS,** even the swelling of natural rubber in oil is utilized in sealing the split and tightening the rings in the PLUNGER GROOVES. **Resistance to abrasion** greatly prolongs plunger life in sandy conditions. **Slippery when wet** means that you have lubrication, even when pumping all water. Barrel life is increased because this material cannot score or gall metal.

For the **REPLACEABLE RUBBER GUIDES** in cages, **oil resistant** synthetic rubber is used. No swelling can be tolerated here. **Resilience** completely eliminates the beating action of the ball, and greatly increases ball life. **Resistance to abrasion** reduces wear on both guide and ball.

CUT YOUR COSTS . . . LET RUBBER TAKE THE WEAR . . . Write for our new 1960 catalog.

JOHN N. MARTIN

Manufacturer

9 W. BRADY STREET • TULSA, OKLAHOMA

Engine Automation Meter

REN Slow-Flow Meter, positive displacement type, has been added to the Power Plus line of engine automation equipment.

It is used in conjunction with the company's oil level regulator for metering the amount of make-up lubricating oil fed by the regulator to engine crankcases and lubricators.

Meter embodies a pressure regulator which permits it to operate from a supply system of from 2-40 lb pressure. Counter registers in gallons and tenths of gallons.

Meter is used on drilling rig engines and generators to accurately meter diesel fuel consumption. *Power Plus Corporation.*

Circle number (9) on reply card.

Drill Pipe Wiper

A rubber drill pipe wiper, the Magic Circle, has been field tested and placed on the market. It has a specially-reinforced inner wiping ring designed to maintain constant wiping pressure on the pipe.

The wiper can be reversed after one side has become worn. Other features are a recessed bowl design, and three drainage ports located at the outer diameter of the wiper to allow drainage.

Wiper is made of special rubber compounds designed to resist tearing action and abrasion, and it is available in sizes from 9 through 17 in. OD to fit all sizes of rotary tables. *Oil States Rubber Company.*

Circle number (10) on reply card.

Chemical Reduces Horsepower

A new chemical that will save operators' money on formation fracturing by cutting horsepower requirements, has been announced by Dowell. The addition agent, they say, will make it possible to fracture wells where, previously, surface pressures would have exceeded safe limitations of well equipment. The chemical, a white powder, is used to thicken water used in formation fracturing operations that apparently gives an unusual slickness property to the fracturing fluid. Friction losses caused when small diameter pipe and tubing are used in well completions are no longer a deterrent to proper hydraulic fracturing techniques because of the peculiar properties imparted to the frac fluid by the new chemical. Higher injection rates are also possible at the same or lower pump pressures.

The chemical is easily mixed into the water that is used for the fracturing medium. It is nontoxic, easy to handle, presents no safety problems and is now available and has been in actual field use in certain areas for several months. *Dowell Division, Dow Chemical Company.*

Circle number (11) on reply card.

Fluid Level Control

Hydrostatic pressure switch provides a control for fluid levels in tanks. It operates gathering systems and pipeline pumps.

Switch is installed in the market line when used as a level control, and it detects variations in the hydrostatic head in the tank, starting pumps at any desired high level and stopping at any low level. It can also be used to operate alarm systems or motor valves.

External installation eliminates cutting holes in the tank, and it reduces electrical expense. Simple screw adjustments allow controlled levels to be changed without removing or relocating the control. *Engineered Oil Controls Ltd.*

Circle number (12) on reply card.

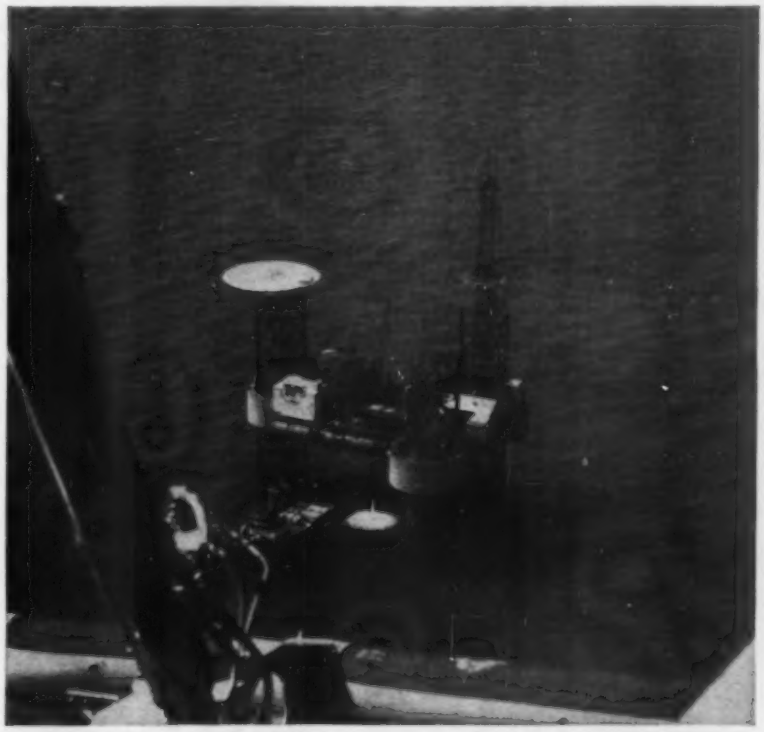
Transistorized Level Switch

Transistorized Model B-07 Electr-O-Probe Level Control is a compact electronic level switch that has been field-tested for suitability in high and low level detection of liquids.

Level control has a solid state circuit design which eliminates uses of vacuum tubes and results in greater sensitivity and stability.

Important features of this new control are unitized, explosion-proof construction; choice of failsafe or direct action; and models available for operation on 115 v, 60 cycle a-c (standard), 12 or 24 v d-c. *Instruments, Inc.*

Circle number (13) on reply card.



Out where dependability counts . . . Rockford Power Take-Offs

Complete self contained units designed to make a hard job easier. Built for every type of stationary equipment. Handle 5,000 lb. thrusts with no external Bearing supports. Specified by more and more oil men for the right way to get more power per ounce of fuel. Write for complete details . . .

ROCKFORD CLUTCHES

ROCKFORD CLUTCH DIVISION BW BORG-WARNER

1303 EIGHTEENTH AVE. ROCKFORD, ILLINOIS

Export Sales Borg-Warner International 36 So. Wabash, Chicago, Ill.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Direct Reading Dynamometer

Two capacities, 150,000 and 200,000 lb have been added to the Dillon direct-reading, traction-type Dynamometers (portable force-measuring instruments). Fifteen capacities from 0-500 lb up to 0-200,000 lb are now available.

Both new units have a net weight of 23 lb, independent of shackles, pins and shunt bar, and have highly visible 10-in. diameter dials. *W. C. Dillon & Company.*

Circle number (14) on reply card.

Submersible Well Pump

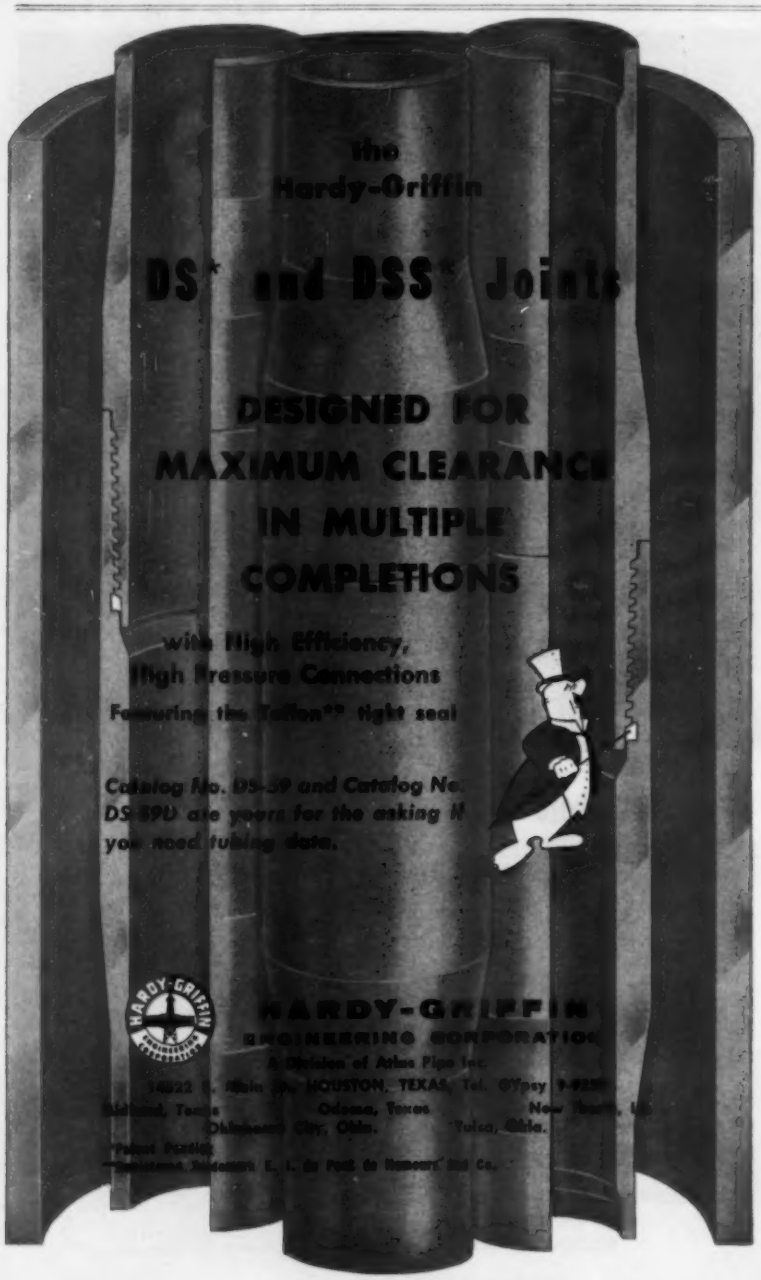
NOYNO submersible oil well pump is designed to extract hard-to-get oil from low-volume, shallow depth wells.

Completely submerged within the well, they eliminate pumping jacks, sucker rods, above-ground motors, gear boxes, and pulley systems. A unique progressing cavity design enables them to handle a full range of high gravity oils with entrained sand and silt.

Using only a single moving part, a hard, chrome-plated tool steel rotor turning within a special oil resistant rubber stator, they have no delicate vanes, turbines, or impellers that may be damaged by contaminants and corrosion.

Submersible pumps are easily moved from one well to another, and since they are installed underground they are protected from extremes of weather and other hazards. *Fernholtz Machinery Company.*

Circle number (15) on reply card.



Hydraulic Pump Unit

Fluid Power Pumping Unit has a completely closed hydraulic circuit, which is independent of well fluid.

Compressed air in a common accumulator tank above the hydraulic fluid, is used to maintain perfect balance of the rod load. Hydraulic rams are mounted below ground level, reducing overall height and providing accessibility to the well for servicing jobs.

Unit features a unique vane type, reversible hydraulic pump especially designed to soften out the reversing action of the rams. No scavenger system is required because of low fluid loss.

Power fluid, when needed, is lubricated into the system through a small tank connected to the main accumulator. *Fluid Power Products, Inc.*

Circle number (16) on reply card.

Plain-End Pipe Connection Method

Victaulic Company has developed the Plainlock method of piping which affords a simple, leak-tight method of connecting plain-end pipe using positive-grip couplings and full-flow fittings.

Method consists of plainlock couplings and fittings used with plain or beveled-end pipe. Couplings are designed with two bolts for fast, easy installation and are fitted with hardened stainless steel grips that engage the pipe ends and securely lock them together.

Victaulic Triple-Seal Gaskets, molded of the latest resilient compounds, are ruggedly built for use with the method. Fittings are engineered with long radii full-flow sweeps designed for good hydraulics and minimum friction loss. *Victaulic Company of America.*

Circle number (17) on reply card.

5 Plunger Frac Pump

Radically-different quintuplex-plunger frac pump, specially designed for well servicing application, has been developed by Frank Wheatley Pump & Valve. Features of the pump include reduction to 5000 lb weight and elimination of 66 percent of customary surge.

Field tests on the pump were recently completed in the Texas Panhandle area.

The pump is small and compact, measuring 46.5 in. by 54 in. Design includes a removable one-piece cylinder head and stuffing box. Offset crankshaft reduces power end loads, contributing to the compact design.

Maximum pressures delivered are 4 in. plunger, 6000 psi at 100 rpm; 3½-in. plunger, 8000 psi at 100 rpm; 3-in. plunger, 10,000 psi at 100 rpm. Top speed is 600 rpm, delivering 15.5 bbl per min at 1000 psi with 4-in. plungers. *Frank Wheatley Pump & Valve Mfr.*

Circle number (18) on reply card.

High Pressure Filter Press

A new high-temperature, high-pressure filter press has been announced by Fann.

The model T 35-A was designed to simulate actual field conditions in testing filtration rate or water loss of drilling muds, cements, and fracturing fluids.

The device performs a test in one hour. Features include maximum head pressure, 5000 psi; maximum back pressure, 400 psi; maximum temperature, 375 F; filtering area, 3.53 sq in. (one-half API standard for low-pressure apparatus. *Fann Instrument Corporation.*

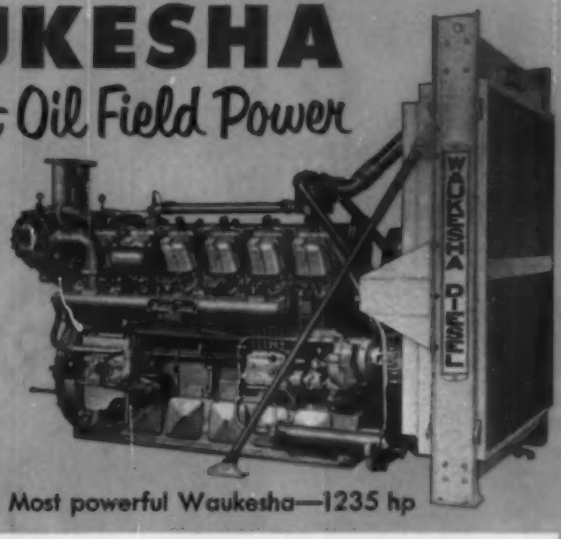
Circle number (19) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

NOT ONLY **WAUKESHA**
the World's Finest Oil Field Power

- GAS GASOLINE
- NORMAL DIESELS
- TURBOCHARGED DIESELS

4-cyl. • 6-cyl. • 12-cyl.



Most powerful Waukesha—1235 hp

AND

WAUKESHA
ENGOMATIC
POWER CONTROL SYSTEM
. . . for automatic engine operation

by Remote Control . . . Time Cycle . . .
Liquid Level or Temperature Differential . . .
Radio Impulse . . . or by any Signal
peculiar to the equipment involved!

NOW *a complete line of* **CONTROLS**

for WAUKESHA **ENGINATORS®**

- TOP-GENERATOR MOUNTED PANELS
- SIDE-GENERATOR MOUNTED PANELS
- EXTENDED BASE PANELS
- WALL MOUNTED PANELS
- FLOOR PANELS
- AUTOMATIC START-STOP PANELS
- AUTOMATIC BATTERY CHARGING PANELS
- AUTOMATIC LOAD TRANSFER SWITCH PANELS

®Registered—ENGINATORS are built ONLY by Waukesha Motor Company, at Waukesha, Wisconsin, and Clinton, Iowa.

482

WAUKESHA MOTOR COMPANY, WAUKESHA, WIS. / **New York • Tulsa • Los Angeles**
Factories: Waukesha, Wisconsin and Clinton, Iowa

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

For your
water flooding conditions,
which is best?

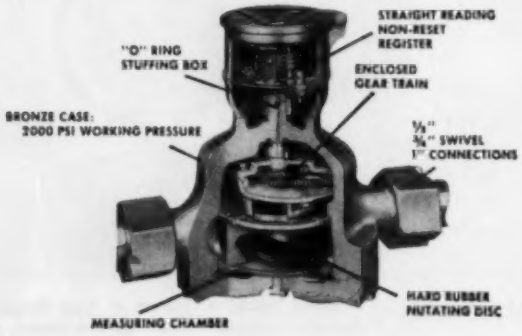
Bronze or Nickel Alloy Meter Parts

You can have either metal in
ROCKWELL "504" FIVE POINTER METERS

For measuring the water input to your wells, which *is* best, bronze or nickel alloy meter parts? There's no pat answer to this one—it depends on the analysis of the water. Bronze is the ideal metal for most services, but where certain corrosive conditions exist, nickel alloy should be used. So, to meet all service needs, Rockwell offers you the option of either bronze or nickel alloy in measuring chambers and in all cases, gear trains of nickel alloy.

Another important advantage in Rockwell "504" Five Pointer meters is safety, since flooding pressures are going up! This meter is designed to operate accurately and reliably without leaks or failures at 2000 psi.

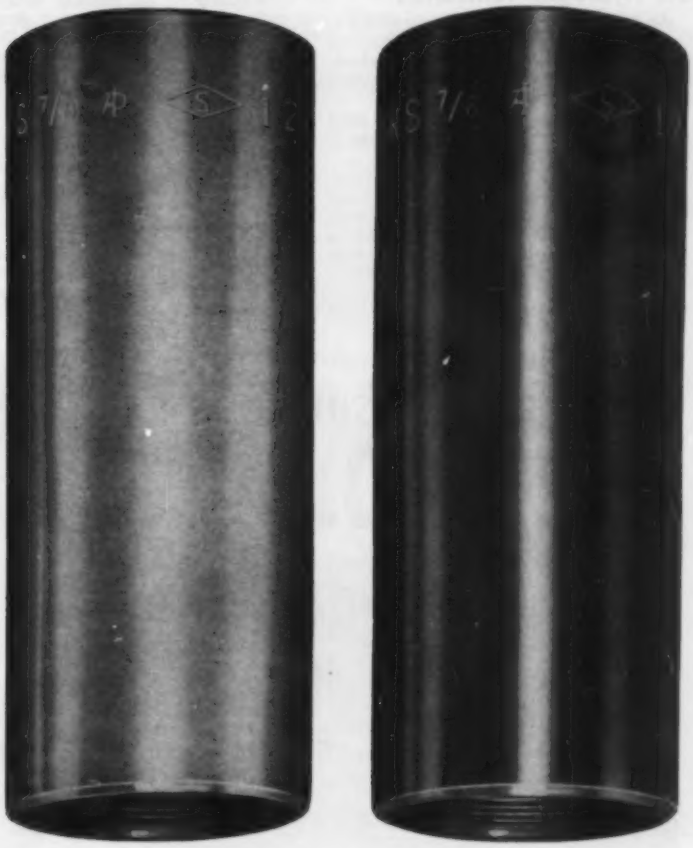
To simplify installation, optional coupling sizes of ½", ¾" or 1" are offered. For full specifications write Dept. 123-E, Rockwell Manufacturing Company, Pittsburgh 8, Pa. Ask for bulletin OG-353. In Canada: Rockwell Manufacturing Company of Canada, Ltd., Guelph, Ontario.


STRAIGHT READING NON-RESET REGISTER
"O" RING STUFFING BOX
ENCLOSED GEAR TRAIN
BRONZE CASE: 2000 PSI WORKING PRESSURE
½" ¾" SWIVEL 1" CONNECTIONS
HARD RUBBER NUTATING DISC
MEASURING CHAMBER

WATER FLOODING METERS
another fine product by
ROCKWELL

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

"Oilwell" Sucker-rod couplings machined from leaded alloy steel at high cutting speeds and finished on a centerless grinder. Couplings are shown *before* and *after* heat treatment.



USS leaded Alloy Steel bars speed up machining...produce a superior finish.

This sucker-rod coupling is a good illustration of how **leaded** alloy steel in the annealed condition can increase machining speeds, produce more parts per hour, and assure an exceptionally fine finish. Cutting tools don't have to be changed as often, threads are smoother and the ends machine accurately. ☐ The steel used in the coupling is leaded, an Open Hearth, Ni-Mo Leaded Steel. Cutting speeds of 268 to 313 r.p.m. were used with an .007" feed producing 550 to 900 couplings before having to change cutting tools. Other users have reported production increases of about one-third over unleaded alloy steel. ☐ If you are looking for a superior product, we urge you to try USS Constructional Alloy Steels, such as 4140, 4145 or 8620 with lead. In addition to good machining, you get high resistance to abrasion and corrosion, better finish and longer product life. ☐ You can obtain USS Leaded Alloy Steel bars and semi-finished steel in all the usual sizes of rounds, squares, hexagons and flats. If the leaded alloy grade you need is not listed here, write or call the nearest office of United States Steel or write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

This mark tells you a product is better because it's steel.

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Instruments Operate On Hydrogen Ionization

An H.F.I. Gas Analyzer and an H.F.I. Gas Monitor, both of which operate on the hydrogen flame ionization method, have been developed by Well Logging Equipment.

The gas analyzer is used in the oil field or laboratory, while the gas monitor is designed for the drilling rig.

The analyzer furnishes chromatographic analysis of hydrocarbon gases with complete analysis through pentane being recorded in five minutes. It has a sensitivity of 5 to 10 ppm of hydrocarbons in 7 scales of attenuation from 1 to 1000.

The monitor continuously monitors hydrocarbon gases in the drilling mud stream. There are no filaments, columns, or thermal cells.

Features of the monitor include sensitivity to methane of 1 to 5 ppm in air, balance which is totally unaffected by high gas shows, 7 scales of attenuation (1 through 1000), pneumatic system that includes metered air dilution for high gas shows, and a low-volume hydrogen requirement that is self-generated and self-consumed as used. *Well Logging Equipment Manufacturing Company.*

Circle number (20) on reply card.

Hydraulic Pump Units

A new line of pumping units, HY-TECO, are hydraulic units manufactured in different sizes and capacities. They range from a 2-in. stroke, 3500 lb polish rod load to 10-in. stroke, 18,000 lb polish rod load.

Units are not counter-balanced, allowing replacement of Jack Lines and Long Tails. However, they can also be used on new wells. Units being built are of a much simpler type than those which are presently available. They incorporate a unique reversing mechanism which simplifies operation and gives the operator more control as to stroke length, operation and maintenance.

Units have ½-in. to 10-in. variation in stroke length, which can be obtained hydraulically by a valve, thereby eliminating the hazard of shutting the well down to lengthen or shorten the stroke.

Hydraulic pumps are directly-driven, eliminating belts and pulleys. High pressure hoses connect all units from the hydraulic power source to the cylinder. *Hydraulic Tool & Equipment Company.*

Circle number (21) on reply card.

One-Trip Casing Pump Packer

A new one-trip casing pump packer that requires no setting tool and needs neither tail pipe nor set-down weight to maintain pack-off is now offered by Baker. It is said to be especially suited to applications where a high volume of high-cut oil is to be pumped without tubing. To run in, the packer is made up on the pump, and both pump and packer are run in on the sucker rods. Thus it is not necessary to make a separate trip to set the packer. It is all done in one trip. Setting, too, is simple. Once the packer is set, and pumping begins, pack-off is maintained by hydrostatic differential. To retrieve, pump and packer are simply picked up with enough pull to overcome the force of hydrostatic head acting on the packer seal area. The packer moves freely in the well when running in or retrieving because the ports let fluid bypass freely through the packer. Ports are sealed off when packer is set. *Baker Oil Tools, Inc.*

Circle number (22) on reply card.

Packer For Tubingless, Conventional Completions

New T-I-W Type AH Packer has been designed for use in both conventional and tubingless methods of well completions, where small sizes of casing, production tubing, or both are used.

Designed and manufactured by Texas Iron Works, Houston, this new packer also features one piece mandrel and ring type packing elements, for positive seal against high pressures.

Packer can be set, released, and reset without affecting the efficiency of the packer, and it is available for 2⅜ and 2⅞ OD casing, with or without hydraulic hold-down slips. *Texas Iron Works.*

Circle number (23) on reply card.

Diaphragm Control Valve

Fisher Type 1664 three-way, two-position diaphragm control valve is designed for oil production work.

Valve has a cast iron body with a 400 psi WOG rating. It is available in the 2-in. size, with either screwed or grooved end connections. The body can be converted easily into a single seat globe or angle body by plugging one of the outlet ports. *Fisher Governor Company.*

Circle number (24) on reply card.

WELL #1

In Galveston County, Texas, a major producing company drilled a virtually trouble-free well. 453 bags of lost circulation material used, of which Pheno-Seal comprised 42%. Mud weight reached 17.4 at TD or 15,200 ft. Production string set and well completed without trouble. Conclusion — exclusive Pheno-Seal trial definitely warranted.

WELL #2

Three miles away, same company went to 100% Pheno-Seal. Mud weight reached 17.9 at TD or 15,500 ft. No trouble logging, including wire line. Ran pipe no trouble. Less protection pipe, higher mud weight and greater depth in same formation as #1. 31% less lost circulation material used. Mud bill reduced over $12,000.00.

FIELD-PROVEN PHENO-SEAL

- Non-Fluorescing
- Will not harm pumps and valves
- 35,000 P.S.I. compressive strength
- Chemically inert — unaffected by temperatures, acids and alkalies
- Reduces friction
- Mixes easily with all types of muds
- Available through your mud dealer.

PHENO-SEAL

A 12-page brochure on Pheno-Seal is available at your request. Just write . . .

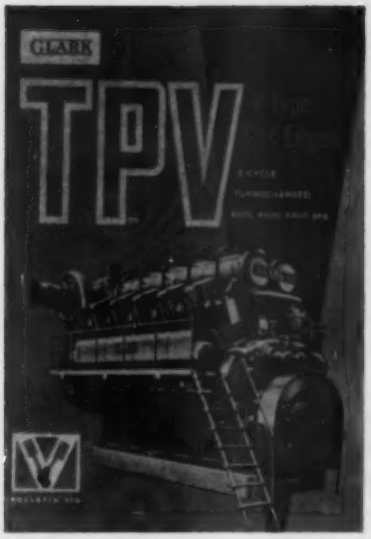
MONTELLO, INC.
Box 5334 Tulsa, Oklahoma

Sales Representatives—

Pheno-Seal Sales Co.
McAllen, Texas ..... MU 6-3943
Lafayette, La. ..... CE 5-6945

Circulation, Inc.
Borger, Texas ..... BR 4-3033
Pampa, Texas ..... MO 4-2671

Drilling-Producing Literature



V-Type Gas Engine Has Turbocharger

Illustrated bulletin 176, issued by Clark Bros. Company, one of the Dresser Industries, introduces the Model TVP, a 2-cycle, V-type, turbocharged gas engine designed as a compact, high horsepower driver for liquid pumps, generators, and centrifugal compressors.

Design features and operating characteristics resulting from joining 2-cycle simplicity and dependability with V-engine compactness are described. The engine has a completely automatic, jet air started turbocharger.

Models are built with 10, 12, and 16 power cylinders, rated at 4000, 4800, and 6400 bhp respectively. *Clark Bros. Company.*

Circle number (25) on reply card.

Glycol Dehydration Unit

Horizontal, skid-mounted glycol dehydration units designed and fabricated by National Tank are described in an 8-page bulletin. Tanks have several unique features designed to eliminate dead spots and non-channelling of glycol.

In the units, horizontal glycol trays have stainless steel, removable caps that automatically control the gas-glycol contact according to the volume going through the system. Caps have three rows of holes that permit the gas to contact the glycol through the first row when flowing slowly, and additional rows as volume increases.

Each glycol pump splits the flow into equal streams of freshly concentrated glycol which flow onto the horizontal trays.

Units are available in many different models and standard working pressures of 600, 1000, and 1200 psi. More than 30 units are now in operation. *National Tank Company.*

Circle number (26) on reply card.

Welding Fittings

A new 32-page catalog, No. 599, on Tubend welding, stainless steel and aluminum fittings is available from the British company B.K.L. Alloys, Ltd. Catalog lists all standard and many special-purpose welding fittings, including elbows, returns, tees, reducers, and caps. *B.K.L. Alloys Ltd.*

Circle number (27) on reply card.

Field, Discovery Maps

Two recently-completed maps are available, an Oil and Gas Field map containing over 1100 fields delineated and names; and a 1959 discovery map indicating the operator, pay zone, and depth for each of the new discoveries. West-Central United States is area covered. *Allstate Map Makers.*

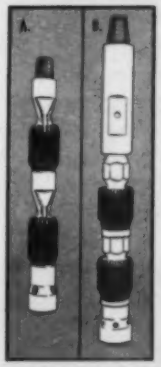
Circle number (28) on reply card.

Screen Pipe

Eight-page catalog describes screen pipe for oil, gas, and water wells, including slotted screen pipe, vertical slotted and drilled-hole wire wrapped screen, ribbed type wire-wrapped screen, and prepacked gravel pack screen. It includes specifications of various types. *Emsco Screen Pipe Company.*

Circle number (29) on reply card.

DESIGN IS IMPORTANT . . . . . RUBBER IS VITAL!



(A) TUBING and DRILL PIPE SWAB
(B) CASING SWAB

Efficient Design means trouble-free operation and more fluid lifted per trip . . .

Engineered Rubber means more trips per cup, more fluid per hour.

OIL STATES pioneered the modern swab design . . . was first with the fluted mandrel . . . first with the free-moving cup for easy unloading and positive valving.

OIL STATES Swab Cups contain rubber engineered for oil field use. Compounded for swabbing by *oilfield rubber specialists* — tops in their field.

The rapid acceptance of the OIL STATES Swab is eloquent testimony to its excellence of design and superior performance. Use OIL STATES on your next swabbing job and be assured of . . . .

"Oil Field Rubber Products Of Matchless Quality."

Oil States **OIL STATES RUBBER CO.**

P. O. Drawer 152 • Arlington, Texas

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Seismograph Systems

Three bulletins describing seismic equipment have been issued by Southwestern Industrial Electronics.

The G-22A seismograph system is a vehicle-mounted system used where wide-range signal handling ability and extensive filtering flexibility are required. The P-19 refraction seismograph system features portability with high gain and low frequency characteristics that allow it to be used for conventional refraction uses, well velocity surveys, and overburden determinations.

Compact, lightweight PMR-20, a portable seismic FM magnetic 24-channel transistorized seismic system, is complete in 2 aluminum-cased units. It provides high-fidelity frequency modulated recordings on standard tapes from output of standard geophysical amplifiers. *Southwestern Industrial Electronics Company, a division of Dresser Industries, Inc.*

Circle number (30) on reply card.

Auxiliary Check Valve

Auxiliary check valve brochure describes basic application, construction features, and operation of Macco's resilient sleeve valve. It is designed for use in multiple completion gas lift installations and pipelines.

Brochure is a 2-page, 2-color publication, complete with illustrations. It presents parts and specifications of Model CM-1 and CM-2 check valves. *Macco Oil Tool Company.*

Circle number (31) on reply card.

RESERVE YOUR SPACE **NOW!**

PERMIAN BASIN OIL SHOW

The 1960 Permian Basin Oil Show will be the largest oil exposition this year. It's your opportunity to exhibit your products or services right in the heart of the oil country directly to the men that use and buy those products.

Be sure your company is represented. Act now for choice space. For complete information write:

Jay Alvey, Manager
Permian Basin Oil Show
P. O. Box 2248
Odessa, Texas

Low-Voltage Electrical Distribution Equipment

General Electric has released its 1960 edition of the Buy Log, GEC-1100B, which covers low-voltage distribution equipment. It is a condensed catalog for service entrance equipment, light and heavy duty safety switches, tumbler and open-knife switches, hinged wireway, circuit breakers, switchboards, motor control centers, sectional distribution centers, and all types of panelboards and busway.

Featured are selector charts for each type of product, pictorial descriptions, consolidated pricing tables, and a cross-referenced catalog number index.

Also included are ratings, weights, dimensions, standard package quantities, ordering directions, and several pages of general application information. *General Electric.*

Circle number (32) on reply card.

Sand-Control Screen

Sandban screen is described in technical literature available from Dowell. Screen consists of a large, slotted aluminum screen, a smaller slotted aluminum or steel screen inside it, and a permeable network of plastic-coated walnut shells that fill the annular space between the 2 screens.

Porous network prevents sand from entering the well, but does not hinder fluid production. Screen is available in 3 sizes, 4-in. OD with 1½ in. steel screen inside; 5 9/16 in. OD with 2⅜ in. steel screen inside, and 5 9/16 in. OD with 2 in. aluminum screen inside. Other sizes can be made to order. *Dowell, division of The Dow Chemical Company.*

Circle number (33) on reply card.

Jet Perforator For Ultra-Slim Casing

The 1 11/16 in. Ribbon Jet is a semi-expendable tool designed principally for 2⅜ in. casing perforations, and it is described in a 6-page engineering report. Tool is intended to minimize gun debris, which prevents casing bridging and excessive well fill up.

Gun may also be applied to 2⅜ in. size casing, and it is basically a retrievable flat steel ribbon design. The ribbon serves as a carrier for a specially designed encapsulated charge.

Conventional firing system consisting of pressure-resistant primacord and detonator is employed. Bulletin gives complete description and lab test results. *Schlumberger Well Surveying Corporation.*

Circle number (34) on reply card.

Speed Reducers For Pump Operations

Methods of speed reduction with compact, shaft-mounted units in a wide range of sizes and horsepowers are described in 64-page Bulletin A692 by Dodge Manufacturing.

Besides an expanded line of Torque Arm Speed Reducers for mounting on shafts of driven machines, the bulletin also presents reducers for flange mounting, vertical shafts, right angle drives, and screw conveyor drives. *Dodge Manufacturing Corporation.*

Circle number (35) on reply card.

"Be sure you use Milwhite Products"

Milwhite Drilling Benefits: New Products, More Research, Comprehensive Communications, Highly Trained Engineers, a new Stockpoint Building Program and a Real Mud Service the industry has needed for a long time.

MILWHITE

MUD SALES COMPANY

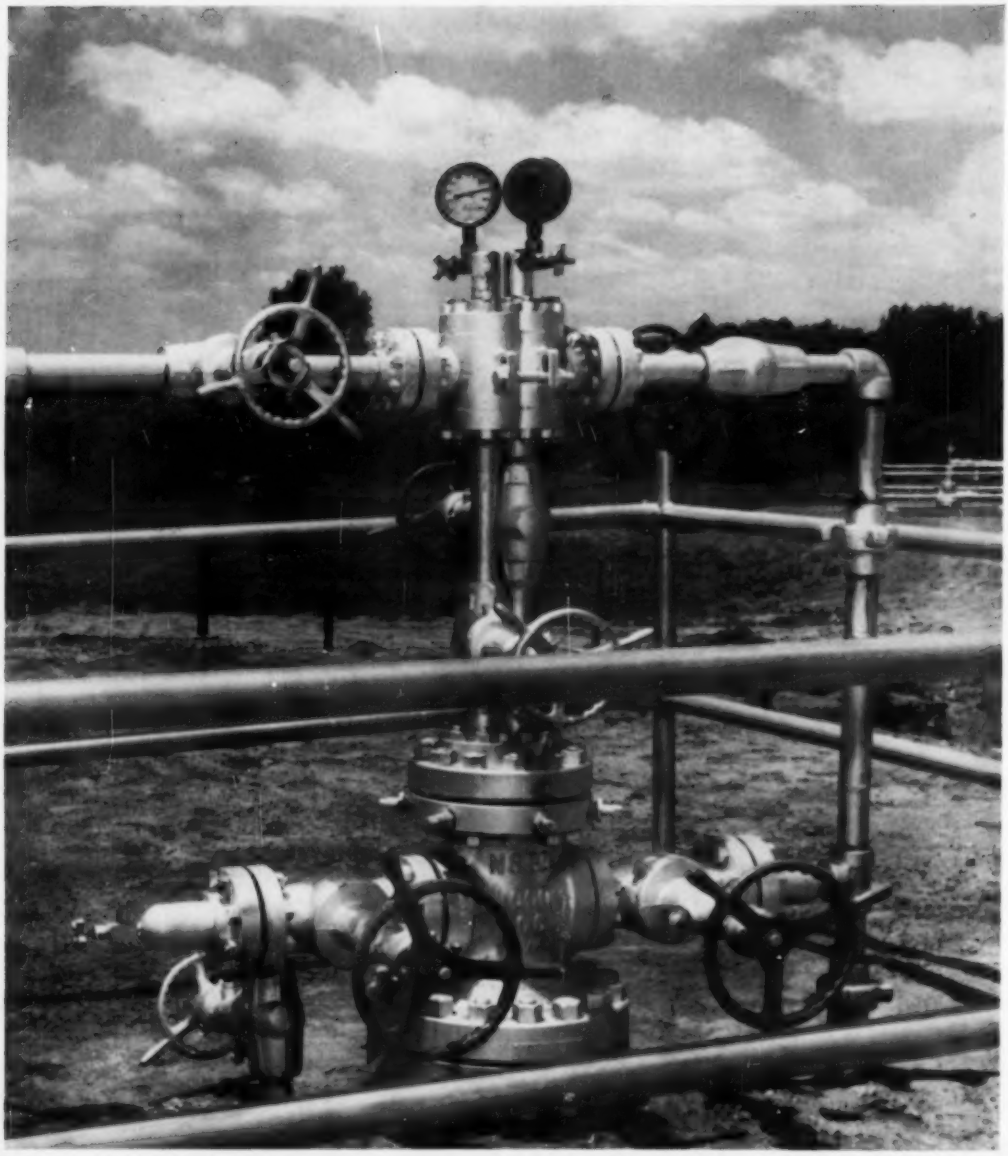
HOUSTON, TEXAS

DIVISION OF MISSISSIPPI RIVER FUEL CORPORATION

ORBIT VALVES®

You will profit by talking to an **ORBIT** representative or to your favorite well head manufacturer about Orbit Valves for dual hookups

Orbit Valves are available also for Triple Hookups—working pressures up to 3000 lbs.



ORBIT VALVE COMPANY

BOX 699 / TULSA, OKLAHOMA / U. S. A.

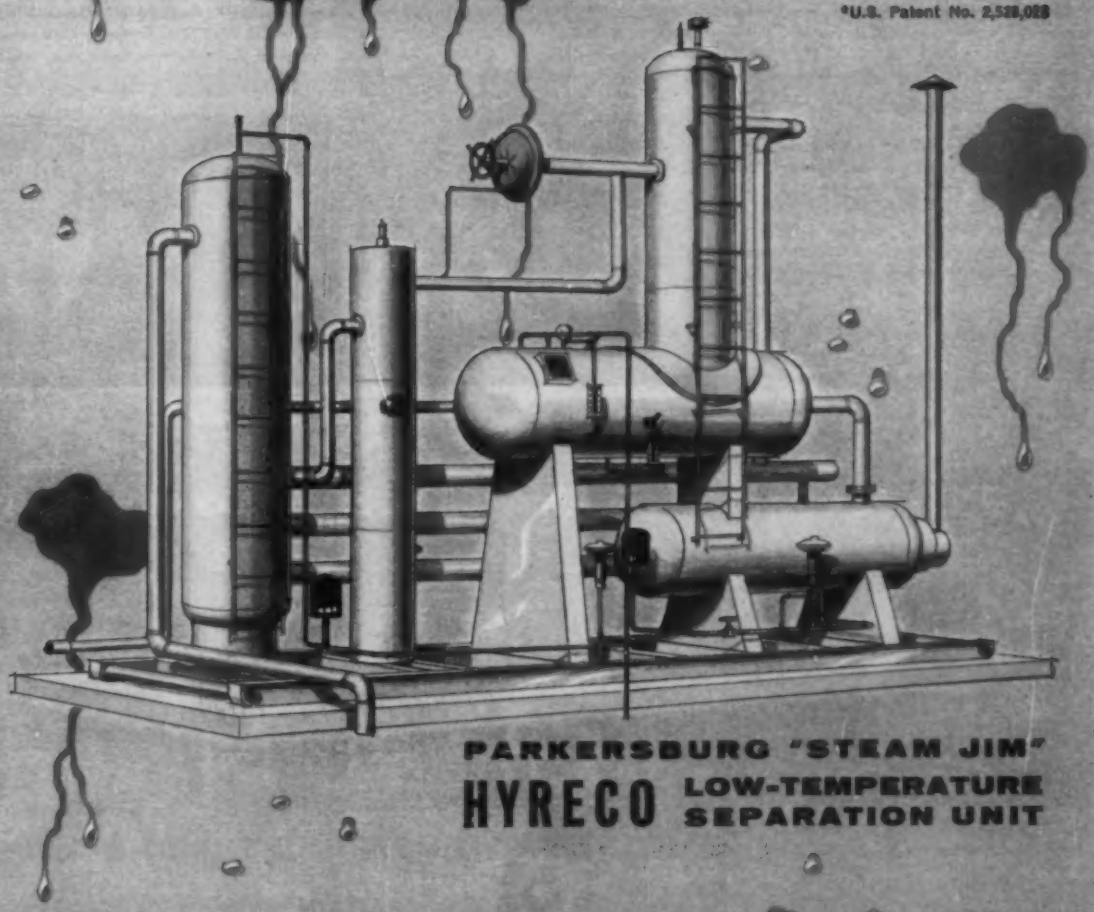
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

WE'RE ALL

"STEAMED UP"!

. . . about the steam generator we've added to our "Slim Jim" Hyreco unit. You gain two ways . . . complete unit portability and less capital investment . . . and, of course, the patented* T-Bone design in our "Steam Jim" is the outstanding cold separation unit in the industry. Minimum gas reheating, minimum fuel requirements, and minimum corrosion problems are additional bonus values with this Parkersburg unit. Parkersburg's Hyreco low-temperature separation process sets the standard for the petroleum industry.

*U.S. Patent No. 2,528,088



PARKERSBURG "STEAM JIM"

HYRECO LOW-TEMPERATURE SEPARATION UNIT

PLUS FEATURES

- Removable firetube
- Factory-insulated
- Aluminum cover
- Unitized or remote-mounted
- Completely piped for field installation

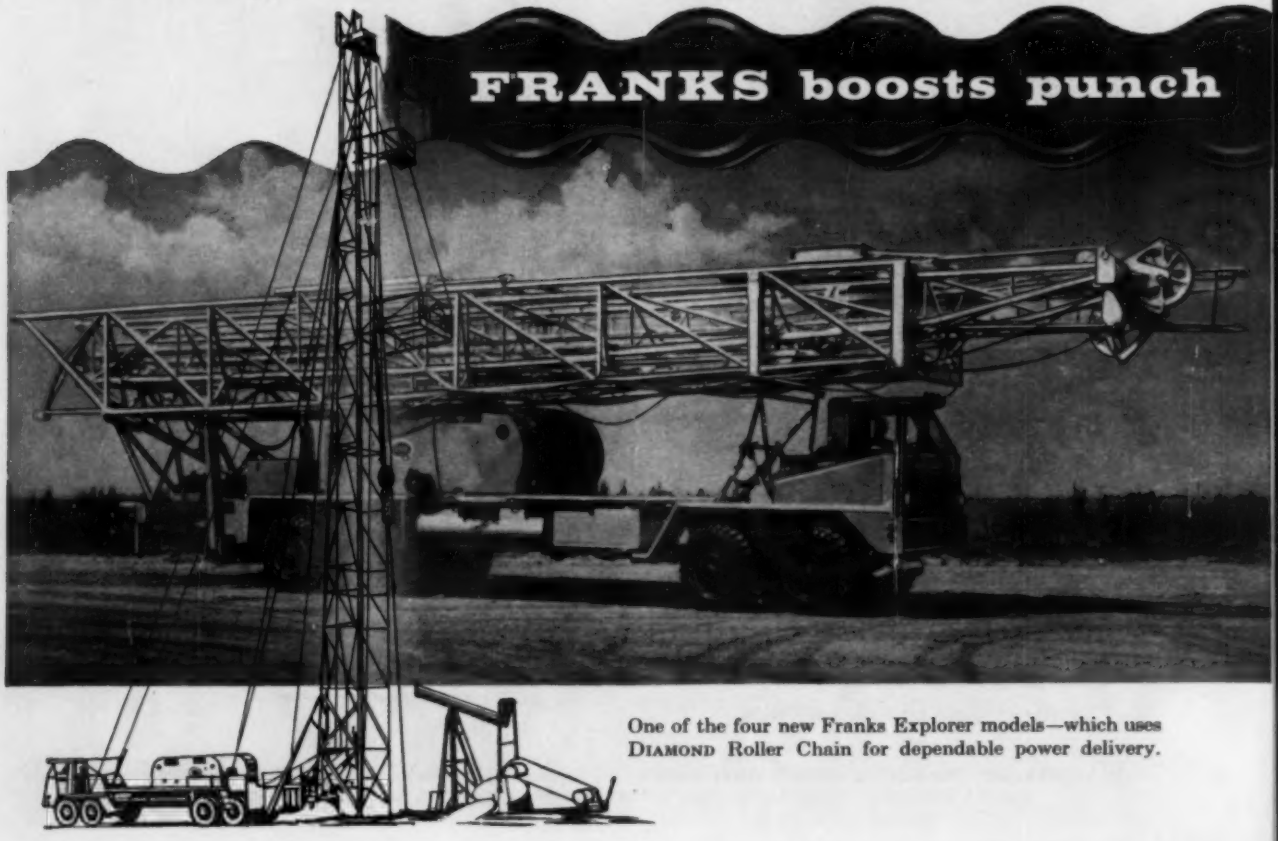
THE PARKERSBURG RIG & REEL COMPANY
Division of Parkersburg-Aetna Corp.
PARKERSBURG • HOUSTON • COFFEYVILLE

PARKERSBURG—The FULL LINE in Pressure Vessels . . . Separators, Metering Equipment, Treaters, Heaters, Knockouts and Oil Skimmers, Scrubbers, Hyrecos, Hydrocarbon Recovery Units, Glycol Dehydrators, Stabilizers.

THE OASIS — A gathering spot for NOMADS

1960 officers of the Los Angeles Chapter of Nomads elected at 21st annual inaugural ball are left to right B. Bronzan of McCullough Tool Company, deputy sergeant-at-arms; Willard Goertz of Monarch Engineering Corporation, assistant treasurer; P. M. Bowen of Martin-Decker Corporation, treasurer; Lester G. Evans of Axelson Manufacturing Company, secretary; Charles M. King of Baker Oil Tools, Inc., vice president; Tom R. Ashe of Globe Oil Tools Co., regent; Taylor Bannerman of Technical Oil Tool Corporation, president; Earl M. Daniels of Hydril Company, regent; Robert P. Gaylord of Wagner-Morehouse, Inc., regent; C. C. Sutton of Oil Well Manufacturing Company, assistant secretary, Jack S. Smith of Byron Jackson Tools, Inc., sergeant-at-arms.

Tulsa Chapter NOMAD officers elected for 1960 are Oscar B. Irizarry, senior regent; T. D. Williamson, Jr., deputy sergeant-at-arms; John Pearce, third year regent; Paul V. McGivern, president; Harry S. Horton, secretary; R. R. Matthews, assistant treasurer; Larry Harper, sergeant-at-arms; T. M. Lumly, junior regent. Other officers, back row, are Floyd C. Cummings, assistant secretary; W. O. Timberlake, vice president; and E. M. Donovan, treasurer.



One of the four new Franks Explorer models—which uses DIAMOND Roller Chain for dependable power delivery.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Dallas-Ft. Worth NOMAD Chapter 1960 officers are, at the top, R. E. Elmore, Rollo Davidson, and Courtney J. Berlin, regents; Middle, J. A. Kelly, vice president, Dallas; Eric Sutton, deputy sergeant-at-arms; Ramon H. Robinson, sergeant-at-arms; bottom, Charles Edd Trapp, vice president, regional; Robert H. McLemore, executive vice president; Harry S. Zane, Jr., president; William C. Brooks, vice president, Fort Worth; K. Marshall Fagin, treasurer. Other officers not pictured are G. A. Holloway, secretary; T. Gayle Whiddon, assistant secretary, and Webb M. Sowden, assistant treasurer.

Houston Chapter NOMAD officers elected for 1960 are, front row, E. W. Louden, Jas. B. Hughes, B. H. Pickard, all national regents; John W. Gates, president; and Bruce Barkis, vice president. In the back row are J. W. Wallace, sergeant-at-arms; Kenneth P. Morris, assistant treasurer; Bernard Gross, treasurer; Fred A. Christanelli, secretary; Beau A. Wendt, deputy sergeant-at-arms; Terry W. Russell, assistant secretary.

of new power-packed EXPLORER

with

DIAMOND roller chain

DIAMOND Roller Chains deliver power with a punch—up to 400 horses—from this new, powerful, self-propelled servicing and workover rig. *Dependable* power is important. That's why more and more equipment manufacturers rely on DIAMOND Roller Chain for greater strength, longer wear and highest efficiency under the most rugged oil field conditions. Specify DIAMOND for economy too—your oil field store carries complete stocks.

DIAMOND CHAIN COMPANY, INC.

A Subsidiary of American Steel Foundries

Dept. 441 · 402 Kentucky Ave., Indianapolis 7, Indiana

OFFICES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

TULSA OFFICE:
2238 Terwilleger Blvd.
Telephone: RI 2-1960

For name of your DIAMOND chain supplier, see the Yellow Pages of your phone book under the heading of CHAINS-ROLLER.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

What's doing in DRILLING

New Portable Rotary Drill Introduced

Designated as Model 10-R, Bucyrus-Erie Company recently demonstrated this new rotary drilling machine at the Griffin Tank and Welding Service yard located in East Dallas. The new 10-R rotary is rated for depths to 1000 ft using 2⅞ in. drill pipe. It is truck mounted and is equipped with both a mud pump and air compressor for either method of drilling.

Ruggedly built, the new rotary features a unit style construction. A conveniently located two-level driller's control panel provides complete and rapid control of every drilling operation. A BECO developed unitized split shaft power take-off transmits the truck engine power to all machinery components.

The rig is equipped with double drum drawworks, tandem mounted, on a live driving shaft. Each drum has a very compact BECO high-torque clutch and a full capacity heavy-duty band brake. An optional third drum or sand reel can be mounted above the drums.

The oil bath rotary table has precision spiral bevel gears and a 5¼ in. opening. It is controlled by an independent friction clutch and a 4-speed forward and reverse transmission, permitting a range from 40 to 250 rpm. The table can be locked automatically or manually.

A hydraulic power control unit operates a rotary table retracting mechanism (optional), the mast hoist and pull-down system. The 5 by 6 ft mud pump is V-belt driven from the PTO and controlled by an independent friction clutch. The air compressor is similarly driven, permitting an almost immediate change of the circulating medium.

The BECO-designed mast is constructed of square tubing and complete upper sections are available to provide various working heights. The standard mast is 33 ft and handles 15 ft drill pipe. By inserting a 5 ft section, 20 ft drill pipe may be used and a still longer section can be inserted for handling range 2 pipe.

Other features of the 10-R are: two-speed hydraulic-actuated continuous chain feed pulldown which maintains a selected constant load on the drill bit, or, a constant feed rate at varying loads; as standard equipment, a 3⅜ in. by 18 ft round fluted kelly (23 ft kelly optional); 1½ in. water course swivel and yoke; a pivot-mounted breakout wrench to accommodate both 2⅜ in. and 2⅞ in. IF tool joints. A drill pipe

When more horsepower is needed . . . . . .

Easy enough, you say, on most rigs. But how about a self propelled rig? The *Wilson Winchmobile*, with cross-mounted engine, or engines, is the answer. Compounded, the engines both drive the winch drums and the rear axles. For really deep wells, this is the answer.

storage rack, screw leveling jacks, dust hood and operators' platform are optional.

The 10-R rotary drill was developed for exploration, seismograph, water well and shallow oil and gas drilling to depths of 1000 ft. It was designed for maximum portability, fast rig up and rig down, smooth and rapid drilling operation and a minimum of maintenance expense.

Acoustical Expert Advises Operator in City Drilling

Soundproofing, screening, and safety activities in preparation for drilling an exploratory oil well in the CP Unit No. 1, about 500 ft southwest of the intersection of Western Avenue and Imperial Boulevard in Los Angeles has been completed.

Derrick and machinery are being soundproofed, and drainage from the well will be diverted into a specially-built concrete cellar to insure there is no flow into surrounding streets.

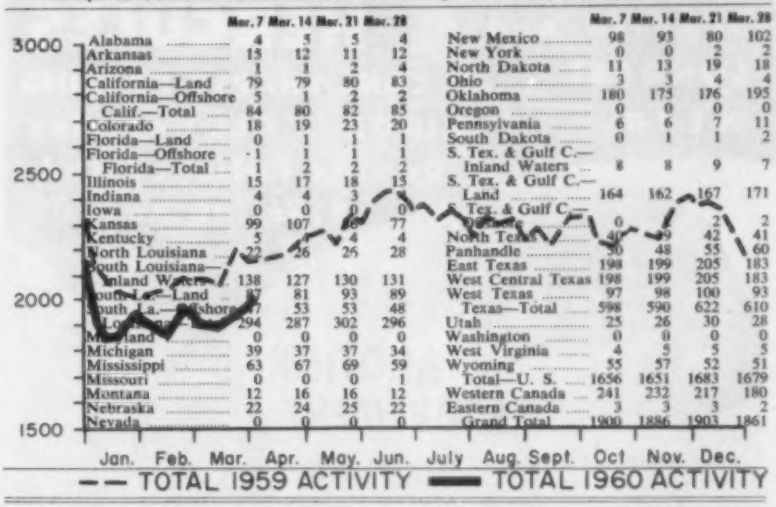
In another city drilling operation, Mobil Oil Company will conduct operations according to the advice of an acoustical expert at a Brentwood Country Club site.

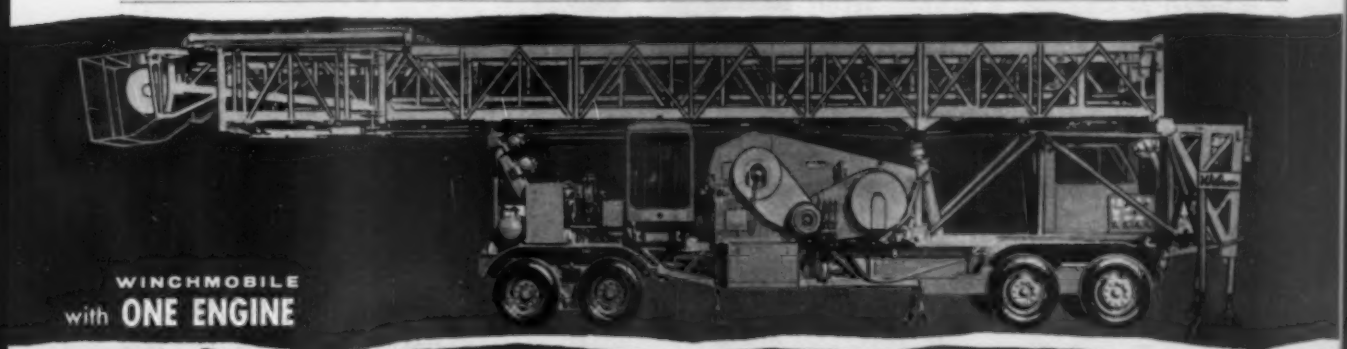
A company representative will explain drilling operations during the daytime to residents of the area and make certain that operations are conducted to conform with strict adherence to regulations.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company.

	Mar. 7	Mar. 14	Mar. 21	Mar. 28
Alabama	4	5	5	4
Arkansas	13	12	11	12
Arizona	1	1	2	4
California—Land	79	79	80	83
California—Offshore	5	1	2	2
Calif.—Total	84	80	82	85
Colorado	18	19	23	20
Florida—Land	0	1	1	1
Florida—Offshore	1	1	1	1
Florida—Total	1	2	2	2
Illinois	15	17	18	15
Indiana	4	4	3	3
Iowa	0	0	0	0
Kansas	99	107	76	77
Kentucky	5	5	4	4
North Louisiana	22	26	25	28
South Louisiana—				
Inland Waters	138	127	130	131
South La.—Land	87	81	93	89
South La.—Offshore	57	53	53	48
[illegible]	294	287	302	296
Maryland	0	0	0	0
Michigan	39	37	37	34
Mississippi	63	67	69	59
Missouri	0	0	0	1
Montana	12	16	16	12
Nebraska	22	24	25	22
Nevada	0	0	0	0
New Mexico	98	93	80	102
New York	0	0	2	2
North Dakota	11	13	19	18
Ohio	3	3	4	4
Oklahoma	180	175	176	195
Oregon	0	0	0	0
Pennsylvania	6	6	7	11
South Dakota	0	1	1	2
S. Tex. & Gulf C.—				
Inland Waters	8	8	9	7
S. Tex. & Gulf C.—				
Land	164	162	167	171
S. Tex. & Gulf C.—				
Offshore	0	0	2	2
North Texas	40	39	42	41
Panhandle	50	48	55	60
East Texas	198	199	205	183
West Central Texas	198	199	205	183
West Texas	97	98	100	93
Texas—Total	598	590	622	610
Utah	25	26	30	28
Washington	0	0	0	0
West Virginia	4	5	5	5
Wyoming	55	57	52	51
Total—U. S.	1656	1651	1683	1679
Western Canada	241	232	217	180
Eastern Canada	3	3	3	2
Grand Total	1900	1886	1903	1861





. . . . add another engine!

BE MODERN — BUY WILSON

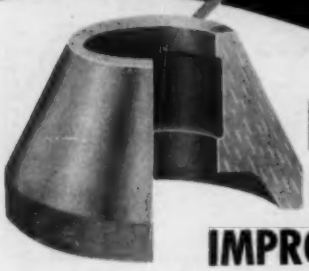
Wilson Manufacturing Co., Inc.

Wichita Falls, Texas — The Home of Red Iron

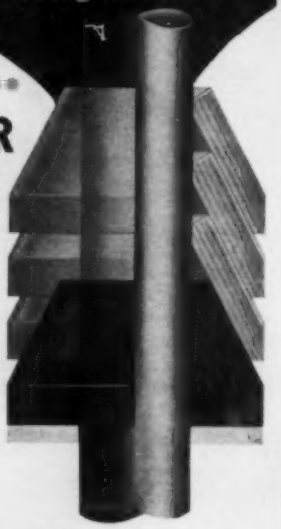
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

for BEST SERVICE and LONGEST WEAR..

...use ONLY HERCULES CONE-SHAPED PACKING RINGS in ALL Hercules Duplex Polished Rod Stuffing Boxes



NOW... ANOTHER IMPROVEMENT



After months of exhaustive field tests, HERCULES is now including a NEW, SOLID Split Bottom Cone Packing Ring in each set of HERCULES Cone Shaped Packing Rings at no extra charge. This new Split Bottom Cone Ring is solid, providing greater contact with the polished rod and a more substantial base for the upper Packing Rings, resulting in longer packing life. A complete set of HERCULES Cone-Shaped Packing Rings now consists of three *Regular* and one new *Split Bottom Cone Ring* for greater life and superior performance.

a type for EVERY requirement

1. HERCULES **SOFT** SPLIT CONE PACKING RINGS
2. HERCULES **HARD** SPLIT CONE PACKING RINGS
3. HERCULES **SPECIAL** LUBRICATED SPLIT CONE PACKING RINGS
4. HERCULES **HEAVY DUTY** SPLIT CONE PACKING RINGS

You can't afford to take chances with either "bargain" or "off brand" packing. One failure could be costly. The unique method of adjusting the Cone-Shaped Packing in HERCULES Stuffing Boxes, as compared with methods employed in conventional types of boxes, eliminates the possibility of efficiently or economically using any other type packing in HERCULES Duplex Stuffing Boxes.

ACCEPT NO SUBSTITUTES. Ask for and accept only HERCULES Cone-shaped Packing Rings for use in all HERCULES Duplex Stuffing Boxes.

Look for the HERCULES trade mark on the red and black carton.

All HERCULES Products are Available at Your Supply Store.

HERCULES TOOL COMPANY

Manufacturers of Oil Field Equipment

GENERAL OFFICES AND PLANT • TULSA, OKLAHOMA

Export Representative Oil Field Equipment Co., Inc. 90 West Street, New York, N. Y.

Quick Coupling Developed For Temporary Lines

An electricweld pipe made of lightweight, galvanized steel and equipped with a quick coupling has reduced installation cost on temporary gas and water lines 66 percent, Butler-Johnson, Inc., Shreveport, Louisiana, drilling contractor, reports.

More than 23,000 ft of nominal 2 in. electricweld pipe equipped with Fast-Line Couplings developed by McDowell Manufacturing Company of Pittsburgh, Pennsylvania, are in use at four Butler-Johnson rigs.

Lightness and the pipe's extremely fast, easy coupling system have sharply reduced the labor and time required to lay temporary gas and water lines, the contractor reports.

Only two men are needed to string and couple the pipe, which is made in 30 ft lengths by Jones and Laughlin Steel Corporation's Electricweld Tube Division in Oil City, Pennsylvania.

Fitted with the rapid couplings, pipe lengths are joined much faster than standard threaded and coupled pipe. Leak-proof joints are made up in a matter of 15 to 30 seconds—without tools — merely by hand-tightening a coupling lock nut. An oil and water-resistant sealing gasket seated inside the coupling assures a leak-proof joint.

A two-man crew can lay three miles of this pipe a day, R. W. Williams, toolpusher on two Butler-Johnson rigs operating near Keatchie, Louisiana, commented. "Anyone can lay this pipe," he said. "You don't need tools and you don't need skilled labor."

Although light in weight, the pipe showed considerable strength on this location as it was laid on rolling terrain and did not sag even though it was unsupported.

Pipe and couplings are designed to operate at working pressures up to 600 psi, with a bursting pressure of 1800 psi. Walls of the 2 in. pipe are .049 in. thick; a 30 ft length, complete with couplings, weighs less than 40 lb.

Aerated Sea Water Speeds Rate of Penetration

A well using aerated sea water as drilling fluid and with a pleated canvas sleeve shutting off porous coral at the top of the hole is being drilled by Gulf Oil Corporation near Key West, Florida.

Well is currently drilling below 12,000 ft, in 36 ft of water and is located 35 miles southwest of Key West. Proposed depth of the well, designated Marquesas Well No. 1, is 15,000 ft. It is owned jointly by Gulf and The California Company; Offshore Exploration, Inc. is the contracting company.

A 24 in. hole was drilled to 790 ft, electrical logs were run, and 20 in. casing was set. Pleated canvas sleeve was used to line the porous coral wall of the hole and contain the column of cement pumped around the casing.

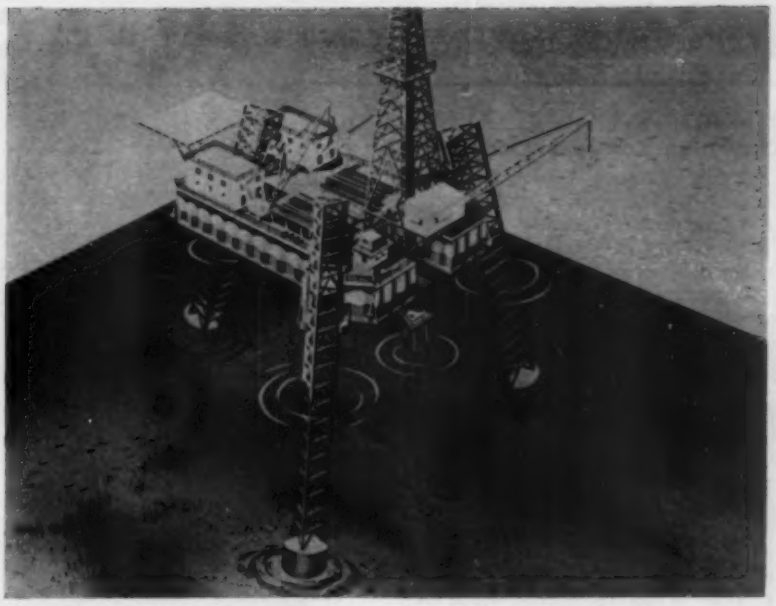
A 12¼ in. hole was drilled to a depth of 7728 ft and aerated sea water was used as drilling fluid. Air was used to lighten the annular column sufficiently to establish returns, since returns would be lost completely in the porous formations.

Tremendous quantities of water are produced from these formations, and returns are 5 to 10 times as much as the water pumped into the hole. This helps to keep the hole clean, and lime is added to inhibit corrosion of the drill string.

Four compressors and two boosters supply air used. Units are rated at 1800 cu ft of free air per minute at 1800 psi maximum pressure, and they are all diesel-powered.

An intermediate set of casing was set at 7728 ft when impervious formations were reached, and thus porous formations up the hole were cased off.

An 8⅝ in. hole is being drilled below this depth, and a total of 4670 ft was drilled in 19 days.



Slant-Legged Mobile Unit Scheduled for Construction

First slant-legged offshore mobile platform, designed for drilling in waters 125 to 150 ft deep, will be built in 1960 by R. G. LeTourneau, Inc. of Longview, Texas. Wide-base platform can be produced at about the same cost as a conventional unit, and it can be modified for greater depths later.

Slant-legged tripod platform designed for used in 150 ft of water can be modified for operation in 200 ft depths for about 6 percent additional cost.

Leases in waters up to 200 ft depth are in existence, and ultimately, depths up to 600 ft will be available.

D.A.B. DE-ACTIVATE BENTONITE

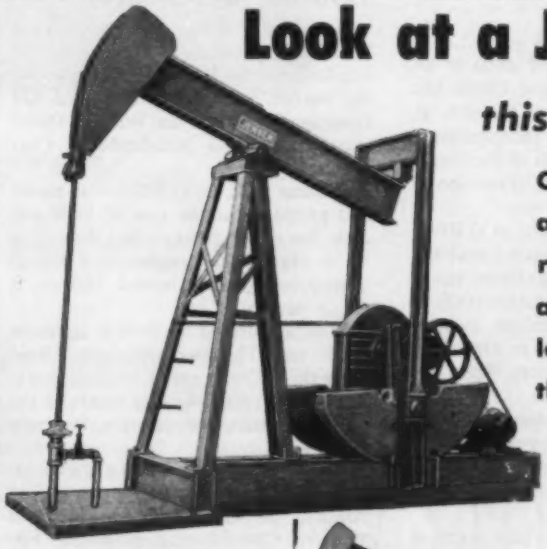
A new chemical additive for water to **permanently** de-activate the swelling of Bentonitic shales and clays. **D.A.B.** controls and limits the amount of water associated with clay swelling. Compatible with all acids and surfactants for the following uses:

1. Oil Well Stimulation and well washing.
2. **Inorganic or organic acid jobs.**
3. Wash — to remove swollen clays — to release water block.
4. **Mud-cake removal.**
5. Completion fluid in conjunction with clay base or oil emulsion muds.
6. **Ordinary clay base drilling mud.**
7. Fracing.
8. **Advance water flood procedure.**
9. Cementing, etc. — whenever it is desired that filtration or encrcachment of water **will not** have a harmful effect on Bentonitic shales or clays.

SIEVERS, INC. 1539 Harbor Ave., Long Beach 13, Calif. Long Beach HEmlock 7-3591 Los Angeles SPruce 5-2891

Look at a JENSEN

this way . . .



Oil production and profit records make a JENSEN look like this . . .

The low cost and operation of a JENSEN make it look like this . . .

Chances are your profit picture isn't as large as it would be if you standardized on JENSENS. Let us show you why!

Made by
JENSEN BROS. MFG. CO., INC.
Coffeyville, Kansas
Export Office
250 Park Avenue, New York 17, N. Y.

STOCKED BY YOUR LOCAL SUPPLY STORE

JENSEN JACKS

EXPLORATION ACTIVITIES

Tennessee Gas Forms Operating Company Overseas

A new operating division has been formed by Tennessee Gas Transmission Company to conduct the company's oil and gas exploration outside of North America.

Tennessee Overseas Company, the new division, will conduct present operations in Argentina, Venezuela, Ecuador, and Bolivia. Tennessee Gas holds acreage and has drilled in all of these countries.

In announcing the development, Gardiner Symond, board chairman and president of Tennessee Gas, commented on his recently-completed tour of company operations in these areas. "Various nations are making prodigious efforts to provide their own source and supplies of fuel and energy, which are so essential to their economic progress and to improvement of living standards of their people."

"They have invited many U. S. companies, including ours, to assist them under terms which are advantageous to both the countries and the companies."

ARCTIC CIRCLE

First Well in Series Spudded Into Tundra

The first of a series of wells to be drilled north of the Arctic Circle has been spudded by Western Decalta, as operator for a group of independents. The well is 40 miles north of the Circle in latitude 67 deg 04 min 30 sec, longitude 128 deg 28 min 00 sec.

Well is known as Decalta et al Rond Lake No. 1, and it is situated near the largest natural oil seepage found north of Norman Wells. The location is about one mile down dip from the seepage and prospects for oil are in Devonian reef similar to the Norman Wells development.

Drilling equipment belonging to Big Indian Drilling Company was barged down the Mackenzie River about 700 miles from Hay River to Fort Good Hope before freeze-up.

A depot was made 16 miles north of Fort Good Hope. A 54-mile bush road was then constructed from the depot to the site at Rond Lake and the equipment was moved in before Christmas. Extreme cold and permafrost present novel and difficult problems for men and machinery in the far north, but they also provide unusual advantages.

Interest in the well is divided among Western Decalta, Supertest, Canpet, New Continental, and Glacier Explorers.

SPANISH SAHARA

Two Companies Planning Their Desert Operations

Two of the companies recently awarded acreage in the Spanish Sahara have announced plans to begin operations immediately. Union Oil Company and Tidewater Oil Company have launched their efforts in advance of the other eight companies or groups awarded concessions recently.

Union will probably be the first American firm to begin exploratory drilling for oil in the Spanish Sahara, E. C. Babson, manager of foreign operations, stated. The first drilling site will be selected immediately after completion of final seismic surveys are now underway, he said.

The three land blocks obtained by Union and its Spanish partner, Compania Iberica de Petroleos, are considered among the choicest potential oil acreage of the Spanish Sahara, Babson said. Two of the blocks have a combined coastline of 50 miles.

The companies have been granted three concessions totaling 1,750,000 acres, and Union Oil holds a 70 percent interest. Union's operating headquarters will be in Las Palmas on Gran Canaria Island, about 144 miles across the Mediterranean from El Aauin.

Tidewater also has announced immediate plans for exploring permits covering about 5,000,000 acres in the Spanish Sahara. Venture covers eight licenses recently granted the two companies by the Spanish government in its territory on the northwest coast of Africa.

Area ranges from the border of Algeria southwestward to the Atlantic Ocean. H. H. Neel, general manager of foreign exploration and production division, and his staff have made a study to determine logistical problems to be dealt with during the geological evaluation.

Tidewater also will base at Las Palmas.

ALASKA

Kenai Wildcat Flows 1870 Bbl Daily on Test

A new oil field was discovered on the 72,000-acre Soldotan Creek Unit of Alaska's Kenai Peninsula, announced the owner companies, Standard Oil Company of California, Western Operations, Inc., and Richfield Oil Corporation.

Wildcat well, SCU 41-4, was tested and produced at the rate of 1870 bbl daily for a very brief period through a ½ in. choke. Well registered a 490 lb flow pressure and showed 260 cu ft of gas per bbl of oil.

Standard drilled the well as operator on the unit. The companies jointly hold more than 92 percent of available acreage on the unit, which is south of the present production in the Swanson River area.

"This new well confirms the commercial oil producing promise of Alaska," H. G. Vesper, president of Western Operations commented. For proper conservation purposes, however, the well could only be produced at a much lower rate than the initial test.

Soldotna well was drilled to a total depth of 11,315 ft on Section 4, Township 8N, Range 9W, about 2 miles south of the nearest Swanson River production. Seven inch casing was cemented at 10,992 ft and additional tests are being conducted in the interval between 10,228 and 10,585 ft in the Hemlock zone.

MISSISSIPPI

Seismic Survey Begun In Mississippi Sound

Shell Oil Company begins seismic exploration in Mississippi Sound to study acreage on 800,000 acres leased recently from the state. Work will continue for one to two years, depending on the type of problems encountered by the water-borne crews.

NEW MEXICO

Gas Wildcat Completed In San Juan County

A gas wildcat has been completed in San Juan County, New Mexico, at the No. 1 New Mexico Federal "N," NW SE SW Sec. 17-30n-12w.

The Sunray Mid-Continent Oil Company well is located seven miles northeast of Farmington, New Mexico, and it is 1½ miles northeast of recently proven production in the Dakota formation of a yet unnamed field.

The exploratory well tested 2,771,000 cu ft of gas a day through ¾-in. choke from the Dakota zone perforated at 6488-98 ft, 6562-74 ft and 6604-08 ft. Tubing pressure gaged 304 lb and casing pressure was 684 lb. Total depth was 6770 ft.

Sunray holds about 2000 acres in the immediate area, and present plans call for additional development on the tract.

Free sets of full-color reproductions of core samples, suitable for office decoration, are available. Request must be made on your company letterhead, and include name of this magazine and date of issue. Address — Core Lab, Box 10241, Dallas 7, Texas.

Underneath Utah

Ismay Formation, San Juan County, Utah: producing depth, 5407 feet; gravity, 41.1° API; permeability, 16 millidarcys; porosity, 15.9%; residual oil, 13.0%; total water, 30.8%.

The successful care and handling of this reservoir began with core analysis — *the very taproot of formation knowledge* —performed by the industry's best reservoir technicians using the industry's finest specialized facilities . . . For the client, it was a sound, *realistic* approach to establish a technical foothold for the development and financial events which follow — completion procedures, fluid studies, special producing problems, long-range evaluation, and probable secondary recovery.

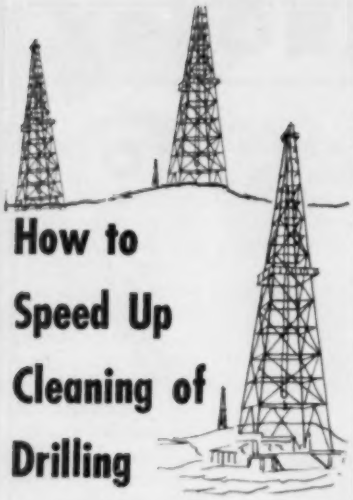
This sample of Ismay Formation represents approximately one two-millionth of Core Lab's reservoir knowledge. Every foot of this experience goes into every job.

CORE LABORATORIES, INC.

BOX 10185 DALLAS 7 TEXAS USA • CABLE ADDRESS CORELAB

CORE LAB

DALLAS FORT WORTH LOS ANGELES BAKERSFIELD LONG BEACH TULSA BARTLESVILLE LIBERAL OKLAHOMA CITY WICHITA WICHITA FALLS CORPUS CHRISTI SAN ANTONIO McALLEN VICTORIA HOUSTON SHREVEPORT TYLER EL DORADO LAFAYETTE NEW ORLEANS HATTIESBURG JACKSON DENVER CASPER CRAIG FARMINGTON KIMBALL STERLING WILLISTON WORLAND MIDLAND ABILENE AMARILLO HOBBS LUBBOCK MONAHANS PAMPA PECOS ROSWELL CALGARY EDMONTON REGINA MARACAIBO BUENOS AIRES BOGOTA TRIPOLI PARIS



How to Speed Up Cleaning of Drilling Equipment

On all heavy-duty drilling equipment such as power units, elevators, pumps, etc., you can speed up cleaning with the Oakite Hurriclean Steam-Detergent Gun.

Here is a handy, lightweight cleaning tool that employs the most potent combination of steam heat, steam blasting power plus detergent.

Try it for rapid cleaning of power slips, catheads, hooks, spiders.

For more information or for on-the-spot technical assistance write Oakite Products, Inc., 47A Rector Street, New York 6, N.Y.

Technical Service Representatives in Principal Cities of U. S. and Canada

Export Division Cable Address: Oakite

OAKITE

over 50 Est. 1909 years' leadership in industrial cleaning

CANADA

Seismic Shot Hole Blows Out at 275 Ft

A 275 ft deep seismic shot hole being drilled as part of The Atlantic Refining Company's exploration of a 2.7 million acre tract in the Canadian Northwest Territories blew out and flowed gas with flames reaching a height of 40 ft. Gas flow was intentionally ignited.

Hole is located about 35 miles west of Fort Good Hope and 10 miles south of the Arctic Circle.

Reports received by the company's producing headquarters in Dallas indicated that the hole had burned for four days without a change in volume. Nature of the gas and underground volume are not known at this time.

Senex Creek Drill Site Staked

Team of Canadian Oil Companies, Home Oil Company, and Aluminex, Ltd. have staked the drill-site for an exploratory test well at Senex Creek in the Buffalo Head Hills area, which is about 60 miles southeast of Fort Vermillion on L.S.D. 6-33-7W5. It will be taken to 4200 ft as a Pre-Cambrian test.

Acreage was acquired under a farm-out agreement from Crusade Petroleum Corporation and its associates, New York Oil Ltd., Dynamic Petroleum Products, Ltd., and Glendale Investment Corporation of Edmonton.

Lands involved in Senex Creek project are located on what is generally known as the Buffalo Head Hills surface anomaly.

LIBYA

Fairchild Makes Survey Covering Barren Wasteland

An aerial mapping assignment has been completed in Libya by Fairchild Aerial Surveys, Inc.

Survey covers 260,000 square miles of Southern Libya's barren, featureless wasteland. It was completed in spite of blistering temperatures, violent dust storms, and unreliable base maps.

Second Deep Test Well Started in Cyrenaica

Second deep test well has been started in the province of Cyrenaica in Libya, British-American Petroleum Company announced. Well site is about 80 miles east of Benghazi, and a rig capable of drilling to a depth of about 15,000 ft is being used.

British Petroleum's first well, which was started last October about 200 miles southeast of Benghazi, has reached more than 10,500 ft and is projected deeper.

Seven seismic survey parties are at work in various concessions that the company holds in Libya. A marine seismic survey is due to start in two Libyan offshore concessions.

KLAMPON

Thread Protector

The Klampon Thread Protector is a neoprene clamping device which provides maximum protection to the threads of all popular sizes and types of oil well casing. This proven device is the most versatile and well engineered casing thread protector available.

Outstanding Features:

- Long life — minimum maintenance.
- One protector operates on all popular threads (API, Exline, Hydril, & Buttress).
- No wrenches, compressed air, or auxiliary equipment required.
- A quick adjustment of tension nut allows rapid change from one type pipe thread to another. (No plugs, liners, etc. necessary.)

For rental throughout the U. S. contact:

LAMB RENTAL TOOLS, INC.
Box #411, Scott Road Phone:
Lafayette, La. CE 5-5588

Limited distributorships now available; write **Lamb Rental Tools, Inc.**
For California rentals and Foreign sales contact home office.

KLAMPON CORPORATION

TEXAS

West Texas Gas Well Flows 102 Mcf on Test

A major gas discovery well with an absolute open flow potential of 102,000,000 cu ft of gas per day has been completed in northwest Pecos County, Delaware Basin, for Socony Mobil.

The deep wildcat well, No. 1 Kathleen Moore, was completed in the Pennsylvanian formation through perforations between 15,041 and 15,147 ft. Surface flowing pressure was 10,240 lb per sq in. through a 9/64 in. choke. This is believed by the company to be the highest pressure gas well ever put on commercial production in West Texas.

Well also flowed 175 bbl of oil in 13 hours between 10,890 and 10,895 ft in the Wolfcamp formation. Production tests will not be run in this formation, however, due to well conditions.

Well blew out at 15,300 ft and was again drilled from 12,676 ft in a side track hole following loss of a string of drill pipe in the blowout.

AUSTRALIA

Tradewinds Plans Drilling on Timor Island

Tradewinds Exploration, Inc. set an extensive drilling campaign for its 4.5 million acre oil and gas concession at Timor Island, 500 miles northwest of Darwin, Australia, on the basis of two encouraging exploratory wells.

Preparations were underway to allow drilling as soon as the monsoon season ends in about 45 days.

Geologists found three structures with a closure of about 500 ft. These were at the western end of the big concession and in relation to prolific seeps which occur on them.

OKLAHOMA

Discovery Well Flows Oil in Okfuskee County

A discovery oil well, the Ambassador-Roman Fixico No. 1, has been completed by Ambassador Oil Corporation of Fort Worth. Well flowed at the rate of 237 bbl of 40 deg gravity oil per day through a 20/64 in. choke from the Gilcrease sand.

Discovery is located in the SE SW Section 32, Township 12 N, Range 9E, Okfuskee County. Nearest production is in the Castle field two miles to the northeast. There are several dry holes between the discovery well and the closest producer.

Well, which was drilled to a total depth of 3566 ft, is producing from intervals at 3366-3368 ft and 3378-3385 ft. Commercial production from the Cromwell sand at 3550 ft also was indicated by drillstem test.

Its mirror-smooth interior walls enable KRALOY PVC PIPE to deliver 20% greater volume.

STOP SOUR CRUDE CORROSION, SCALING, PARAFFIN BUILDUP WITH KRALOY PVC PLASTIC PIPE

Sour crude troubles and tough oil piping problems are today being handled quickly, easily and economically by intelligent application of corrosion-proof KRALOY PVC PLASTIC PIPE. Moisture, rust, rot and gunk don't faze KRALOY. In gathering lines and salt water disposal lines, for example, oil operators and engineers find that KRALOY'S unique qualities handle the job as no pipe of other material can. Amazingly light (⅛ the weight of steel), KRALOY'S high impact rating and flexural strength simplify transportation, handling and laying. Add the ease of cutting and joining KRALOY, you can then save up to 50% in installation costs!

Immune to electrolytic action and sulfate chemicals, KRALOY defies iron oxide salt deposits, resists scaling and paraffin buildup. Inert, corrosion-proof, it remains impervious to soil and most common acids—*never needs painting or cathodic protection*—cuts repairs and maintenance costs to the absolute minimum. Precision extruded, with mirror-smooth walls for maximum line-flow, KRALOY delivers up to 20% greater volume than same-size pipe of other material. Continuous rigid laboratory control insures unchanging KRALOY quality and long life of service. Available in all sizes from ¼" to 12" with plastic valves and fittings; also as U/L listed* electrical conduit in sizes ½" to 6".

**For direct underground burial, or encased in concrete.*

KRALOY PLASTIC PIPE CO., INC., Dept. PE-5
402 West Central Avenue, Santa Ana, Calif.

Please send me a copy of your FREE 36-page Technical Handbook on PVC Pipe.

NAME _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____

NOTHING PIPES LIKE KRALOY

SEE OUR CATALOG IN SWEET'S

Mail coupon today for KRALOY'S free 36-page Technical Handbook on PVC Pipe, packed with information, including flow charts and corrosion resistance chart covering acids, oil, water, gases, and solutions to today's piping problems.

Glass Capsules Aid Sick Wells

THE SPECTACULAR EFFECT of a breaking television tube is caused by air rushing into a vacuum. The forces released by this "implosion" phenomenon cause powerful shock waves. These waves have been harnessed by Dowell Division of The Dow Chemical Company to perform useful work in improving oil, gas, and water wells.

In this service, one or more specially designed and constructed glass capsules are spotted at selected levels in the hole, using either a wire line or a tubing string. The hole is then loaded with fluid and pressure is built up to the pre-determined imploding pressure of the capsule or capsules. A pump truck is generally used to supply the necessary pressure.

When the capsule implodes, fluids in the formation and in the hole rush to fill the void. This results in both a sudden reduction in pressure and a vacuum action which effects cleaning the critical area of the formation. Immediately following this action, a tremendous counterpressure is exerted outward against the formation. The magnitude of this outward pressure, which is almost instantaneous, is dependent on the pressure required to implode the capsule.

The new service has been used for a variety of purposes including fracture initiation in hard-to-fracture wells, formation cleaning to improve production, breaking difficult emulsions, removing scale deposits, and reduction of breakdown pressures ahead of fracturing and acidizing treatments.

The glass capsules are available in various lengths, diameters, and wall thicknesses. Imploding pressures now in use vary from 2200 to 9400 psi, but it is anticipated that this range will be extended from 150 to 10,000 psi in the near future. Size of the capsule employed depends on the job to be done and the hydrostatic pressure of the well at the treating depth. The most common sizes used to date have been 4 by 14 in., 4 by 18 in., and 4 by 24 in.

According to D. D. Setser of Dowell's research department in Tulsa, the implosion technique has been used in approximately 50 wells with interesting results. It may be used to advantage in almost any type of well, either open hole or perforated pipe completions. It has proved of greatest value in hard, dense formations which would not respond to other methods of well stimulation such as hydraulic fracturing or chemical treatment.

The majority of the work done to the formation results from the pressure generated by the second phase of the implosion. The extent of this force may be calculated for an average well application. Assume that a 4-in. diameter capsule, 14 in. long, is to be imploded in a perforated interval at 3000 ft depth in 5½-in. casing. The yield pressure of this capsule is 3300 psi. Since the hydrostatic head of water at 3000 ft is approximately 1300 psi, an additional 2000 psi surface pressure must be applied to implode the capsule. When the pressurized fluid falls 14 in. in the well bore, it has developed 48,350 ft-lb of energy. This potential energy is released at the instant of implosion, and expends most of its energy at 8600 psi pressure against the face of the formation adjacent to the capsule.

It is believed that, during a well treatment, this sudden pressure shatters the adjacent formation, penetrates through localized blocks in the critical area, and provides an easy path for the injection of fluid. It is also believed that numerous short fractures are initiated in the face of the pay, the vertical extent of which is limited by the length of the imploded capsule.

NOW . . . A Complete line of

BrakeSol®

OIL FIELD CHEMICALS

Developed exclusively for solving particular problems in the petroleum industry.

P.T.C. . . . The original Paraffin Treating Chemical. Holds paraffin in suspension from formation to refinery.

DEMULSIFIER D-7 . . . Universal Treating Compound. Gives cleaner oil with less heat resulting in a BETTER PRICE.

STIM FORM® . . . Clean Well Bore! Designed to remove restrictions in perforations . . . face of pay . . .formations

CORROSION INHIBITOR CI-123 . . . Designed especially for control of oil field corrosion problems.

GYP and SCALE TREATMENT GS-20 . . . Effective on these types of carbonates and sulphates: calcium, strontium, barium and magnesium.

FOR INFORMATION . . . Contact Supply Store Brakesol Treating Engineer or write direct!

BrakeSol INC.
REG. U. S. PAT. OFF.

P. O. BOX 9506 • OKLAHOMA CITY, OKLA.
EXPORT DISTRIBUTOR THE NATIONAL SUPPLY CO. EXPORT DIVISION

SUPPLIERS' PARADE

Oilfield Equipment Display Begins 5,000-Mile Tour of Southwest Oil Areas

Ideco Road Show, a mobile display of oilfield drilling, servicing and workover equipment, will visit more than 30 cities, spending two to four days in each, on its 5000-mile tour of the Southwest. The Road Show is a specially designed house trailer and includes working models of rigs and Ideco's complete line of 10 all-steel mud pumps.

A working model of the Duomatic Dual Elevator Pipe Handling System is being shown for the first time. One trailer wall is a frame for photographs of Ideco equipment in the field and literature on all equipment is available. Sales, engineering, and service personnel are available to answer questions.

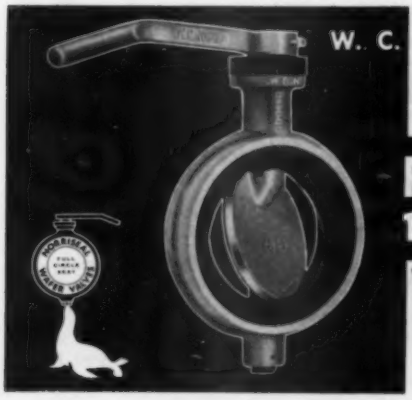
The Road Show is routed through Southern Louisiana, Mississippi, Northern Louisiana, and North Texas. From Wichita Falls the tour goes through Oklahoma and Kansas, then down through the Texas Panhandle, West and South Texas, and finally will return to the Ideco plant in Beaumont, Texas.

Baker Oil Tools, Inc. Baker Oil Tools, Inc. has acquired Hayward Testing Service's cementing collars and related equipment. This equipment, to be known as Baker-Hayward collars, will be marketed and serviced initially in California, and later available in other areas.

Baroid of Canada, Ltd. Operations of Baroid of Canada, Ltd. have been expanded by the completion of a processing plant at Onoway, Alberta, for oil well grade bentonite and barite ore. Other company products will be warehoused and distributed from that point. Future plans include the processing of mud treating chemicals and other mud products. Mining at Onoway will be seasonal but the plant will operate on a year-round basis. T. A. Studer, formerly of Swift Current, Saskatchewan, is plant superintendent.

American Iron and Machine Works Co., Inc. A new machine called "TEDAR" is in use by American Iron for minute measuring of threads on their tool joints. It took more than two years to develop the finished product, which records the actual geometry and dimensions of taper threads by sensing devices which trace and feel the thread. The resulting recordings enable American Iron to regulate quality control and manufacture longer lasting threaded connections.

Tex-Tube, Inc. Art Morton has been named manager of quality control by Tex-Tube, Inc. Company headquarters are in Houston, Texas.



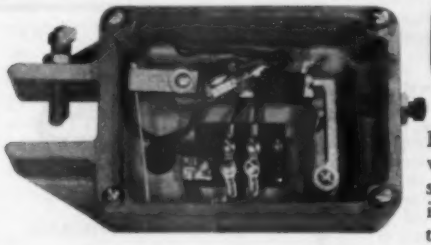
NORRIS

Field Tested and Approved

150 psi working pressure

WRITE FOR NEW VALVE BULLETIN
P. O. Box 1739, Tulsa

VALVES



OVERLOADED?

Here's positive protection against costly breakdowns. The Happy Beam Safety Switch will shut down your pumping equipment when vibration or load reaches the sensitivity for which it is set. A mercury switch opens or closes (depending on whether gas or electric power is used), stopping the operation until the trouble is corrected and the switch reset.

The nominal price of the switch gives you the lowest cost insurance available against costly down-time caused by rods parting and shock loads. Write for descriptive literature and prices.

HAPPY

THE HAPPY COMPANY — DRAWER 770 — TULSA, OKLAHOMA

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

INCREASE PRODUCTION

CLEAN OUT CHOKING SAND

Excessive sand and sediment holds back your oil. For fast, easy cleanout with fewer round trips and less downtime, use world famous Miller Sand Pumps.

Write for descriptive price list.

SAND PUMP SIZES IN STOCK

O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 in. Lengths, 20, 25, 30 ft.

Composite Catalog Page 3400

MILLER SAND PUMPS

Miller Sand Pump Co.

General Offices, Box 4516
Oklahoma City 9, Okla.

EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK 20, N. Y.

For

OPERATING ECONOMY

M&V — M'F'D BY M&V TANK COMPANY — WICHITA FALLS, TEXAS

TYPE P-V
PRESSURE
TREATERS

M&V TANK COMPANY

Wichita Falls, Texas

TANKS-TREATERS
SEPARATORS

Steel Fabrication
for the Oil Industry

Rector Well Equipment Co., Inc. Celebrating the 30th anniversary of Rector Well Equipment Co., Inc., 47 employees representing departments in the United States and Canada met at the general offices in Fort Worth, Texas, for the company's annual sales meeting. J. L. Pinkard, sales manager, presided. L. L. Rector, president, addressed the meeting, outlining company progress and future plans.

The Dow Chemical Company. Roe E. Withrow Jr., formerly a member of the treasurer's staff of The Dow Chemical Company, has been appointed assistant to the president of Dow Chemical International Limited S.A., a Dow subsidiary.

Dowell Division of the company has promoted Gulf Coast personnel. L. D. (Jack) Boughton, formerly manager at Lafayette, Louisiana, is now district engineer, transferred to New Orleans. J. O. Hendrick became manager at Lafayette. B. J. Ladd, for many years in charge of sales at Houma, Louisiana, was promoted to district sales engineer and transferred to the company's New Orleans headquarters.

J. C. Phillipi was transferred from Lake Charles to Lafayette to be area sales engineer. Nolan Pierson, formerly service engineer at Hattiesburg, is now sales engineer at Lafayette. Ed Dronette and J. E. Herbst, former service engineers, are sales engineers at Houma. L. T. McFarlin, T. L. Morris, R. J. Boudreaux, and R. C. Jaynes have been promoted to service engineers.

The Youngstown Sheet and Tube Company. Ending a 25-year association with The Youngstown Sheet and Tube Company, John M. Tuthill has retired. His successor as general manager of sales is John P. DeHetre, who has been assistant sales manager since 1954.

Allis-Chalmers Manufacturing Company. Construction has begun on a multimillion dollar engine manufacturing plant for the Harvey Works of Allis-Chalmers Manufacturing Company. The new plant will enable the company to build a broad line of diesel, natural gas, butane and gasoline engines for varied uses, including oilfield.

Pan Geo Atlas Corporation. Oilfield operations of Pan Geo Atlas Corporation have been extended to the Comodoro Rivadavia, Argentina area. A subsidiary company, Servicios Tecnicos Atlas, S.A. has also been established, with offices in Buenos Aires.

Louis Magnat has been appointed general manager of STASA. Harry Shelton is operations manager.

Grove Valve and Regulator Company. Grove Valve and Regulator Company of Oakland, California, has named James Zenner manager of its Houston office, to act as liaison between the Southwestern field force and the home office.

Jones & Laughlin Steel Corporation. The formation of a Central Region covering Kansas and Oklahoma has been announced by Jones & Laughlin Supply Division. L. B. Rainey, assistant manager of sales-projects, is now assigned in the same capacity to the division's Houston office. Bill Wood, former manager of the Tulsa city sales office, was appointed regional manager.

Norvell-Wilder. The Norvell-Wilder Company is observing its 50th anniversary in 1960. Established by Lipscomb Norvell Sr. and R. G. Wilder Sr. in Beaumont, Texas, the first branch was opened in Houston in 1922. Later permanent branches were established in Shreveport, Fort Worth, Lake Charles, Corpus Christi, Conroe, Odessa; and recently at Baton Rouge, Louisiana and Monahans, Texas.

Norvell-Wilder followed the oil booms of the 1910's and 1920's and in its 50 years of existence has supplied thousands of miles of line pipe, casing, and tubing to major oil companies and independent operators. Recently the company obtained one of its largest orders furnishing material for the largest natural gas processing plant in the world.

Six presidents have served the company since its inception. Lipscomb Norvell Sr., the first president, was followed by R. G. Wilder Sr. The late Edward W. Gildart Sr. served until 1945 and was followed by Lipscomb Norvell Jr. Frank S. Carothers was president from 1949 until his death in 1957. John W. Newton, formerly vice president and manager of refining and a director of Magnolia Petroleum Company, was elected to succeed Mr. Carothers.

The company's capital has increased nearly 70 times and quarterly dividends have been paid for over 45 years. During the two past years, under the direction of John W. Newton, expansion has been rapid. New warehouses and sales offices have been opened, three specialty divisions have been created, and the general office in Beaumont has been enlarged.

The Parkersburg Rig & Reel Company. Reorganization effecting the formation of eight sales divisions in the United States and Canada has been announced by The Parkersburg Rig & Reel Company. Managers of new divisions are: C. E. Hall, California; W. J. Slaughter, Rocky Mountain; M. L. McLafferty, Canadian; C. M. Ferguson, Mid-Continent; R. H. White, Midland; G. W. Hendricks, North Texas-North Louisiana. J. M. Baldridge and L. R. Latimer continue as managers of the Gulf Coast and the Eastern divisions respectively.

Bowen Itco, Inc. The Kinzbach Tool Company, Inc. has been purchased by Bowen Itco, Inc. Occupying adjoining property in Houston, Texas, the two companies have long been closely associated. Bowen Itco, Inc. has 21 sales, service and warehouse facilities in domestic producing areas and 13 export agents located in strategic oil areas abroad.

Payne Manufacturing Company, Inc. Two new appointments have been announced at Payne Manufacturing Company, Inc. W. E. (Bill) Webster is now vice president and B. H. Dykes is sales manager for both domestic and foreign operations.

SECONDARY RECOVERY

PETROLEUM ENGINEERS — STEPHENS ENGINEERING — WICHITA FALLS, TEXAS

RESERVOIR ENGINEERING

Water Flooding **Gas Repressuring**

EVALUATION **CORE ANALYSIS**
SURVEYS **ECONOMICS**

Cost Estimates, Design, Installation
FIELD SUPERVISION
Phone 723-2167

BOOKS TO READ

▸ **Oil Property Evaluation,** *by John Campbell. Published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey. Price, $12 on approval.*

Practical and comprehensive, this book is authored by an industry and educational authority in the field of oil property evaluation, Dr. John M. Campbell. It is an up-to-date study of the latest methods covering the fields of general economic considerations (part I), the engineering analysis (part II) and the economic analysis (part III).

Six chapters are devoted to part I, covering the basic elements of oil property evaluation, economic structure of the entire industry, and the forecasting of demand trends. Chapters 5 and 6 discuss the "value of money" and a broad look at taxation of oil properties.

The 10 chapters covering engineering analysis, part II, comprehensively outline the techniques and equipment presently available to calculate oil and gas reserves and predict future reservoir performance.

Part III, economic analysis, contains 4 chapters dealing realistically with the estimation of costs and the analysis of profitability. Evaluation of processing facilities and the evaluation report itself are also covered.

The book contains over 150 figures and graphs to clarify and guide the reader through the many necessary calculations. Material was drawn selectively from the fields of engineering, economics, accounting and law. All the material used is thoroughly proven and is in practical usage today by professional and operational personnel. The treatment is unusual and much of the material appears for the first time in book form.

▸ **Petroleum Engineering . . . Drilling and Well Completions,** *by Carl Gatlin, Published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey.*

The 15 chapters in this book present an integrated picture of drilling and completion operations as they are normally encountered by the petroleum engineer. And while the latest and most advanced techniques are discussed, the author has also included sufficient basic and general information to permit those not already expert in this field to find material of interest . . . and to receive aid from this basic material in understanding the more advanced precepts.

In addition, the large volume of reference material cited at the end of each chapter adds to the completeness of the fields covered. Especially helpful to the non-technical reader are the many problem examples which are clearly and completely developed, including the answers.

Another plus value:

INHERENT LUBRICATING QUALITIES BROADEN USE OF SEECO-MUL AS E-P ADDITIVE

On your next well, try Seeco-Mul Drilling Mud Emulsifier as an extreme pressure additive. Many operators have recently discovered this extra advantage in Seeco-Mul; in fact we can show you data on a number of field wells drilled under almost identical conditions that will convince you that Seeco-Mul is the most effective E-P agent you can use.

The efficiency of Seeco-Mul as an E-P agent is due to its chemical structure—the ability of one end of the Seeco-Mul molecule to adhere tightly to a metal surface, attracting another molecule to form the familiar micelle, or the joining of two molecules at opposite ends. This layer attracts other Seeco-Mul molecules, which build up to an extremely tough lubricating film that is difficult to remove and will withstand high pressure, successfully reducing metal-to-metal contact and subsequent wear, or galling, of the bearing surfaces.[1]

In addition to the E-P qualities, you get many other advantages with Seeco-Mul. Inasmuch as Seeco-Mul is a chemical emulsifier with superior wetting abilities, it is often run in so-called "soap" drilling fluids (the addition of detergents to fresh water muds, oil-and-water, and water-clay systems) to lower the surface tension, thereby wetting the formation ahead of the bit and keeping the bit clean. Such systems also afford a faster penetration rate and aid the suspended solids to drop out in the pits.

Too, with good lubricating qualities in the mud, less drill stem torque is required, pump pressures can be lowered and more evenly sustained, and a higher velocity of the fluid on bottom can be obtained . . . all of which means longer service life for liners, collars, tool joints, drill pipe, and the bits themselves.

Add to this the longer bit runs and the consequent savings in bits and rig time and you will agree that adding Seeco-Mul to the system is an investment rather than a drilling expense.

Let us show you how you can use Seeco-Mul profitably. We'll gladly send you illustrated literature and a lab sample of Seeco-Mul, or contact your local mud dealer. You can get full particulars without obligation.

[1] *McCutcheon, John W., "Synthetic Detergents."*

Make a good mud better...use

CROSSETT **Seeco-Mul** **DRILLING MUD EMULSIFIER**

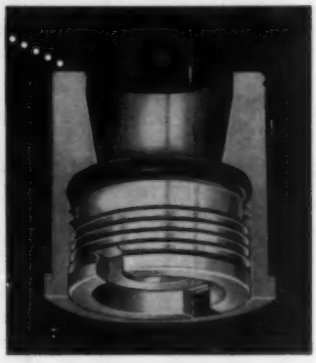
Manufactured by the Chemical Division of The Crossett Company, Crossett, Arkansas

Seeco-Mul is the dried flake form of a compound of the sodium salts of abietic, linoleic, and oleic acids, together with quantities of wood tannins and lignins.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

B-145

Smith Threaded Flow Nozzle sectioned to illustrate O-Ring and general construction



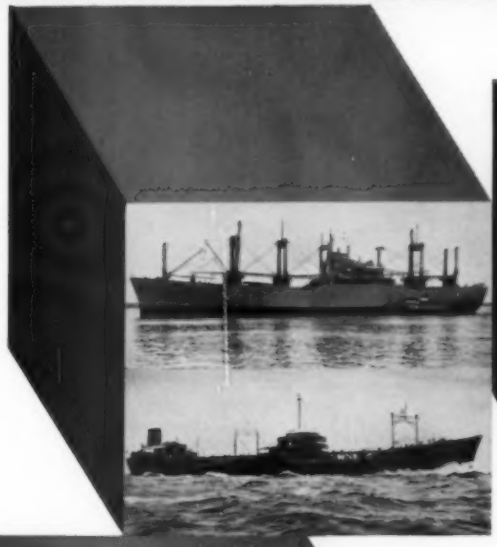
Smith TOOL CO.

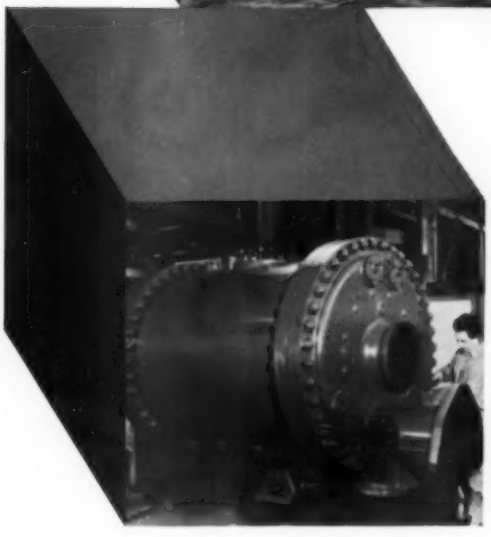
(FORMERLY H C Smith OIL TOOL CO.)

COMPTON, CALIF. •

Branches in Principal Oil Centers Throughout the World

THE JET BIT WITH THREADED FLOW NOZZLES





SUN SHIP
built 'em all....

Our reputation as "master builders for land and sea" is based on 44 years' service to the oil-refining, chemical and other industries.

Frequently we are called upon to produce components for the building of large plants. Our manufacturing and fabricating skills, our understanding of industry's problems are reflected in the variety of equipment we build, like the fractionating towers and special pressure vessel shown here.

In our complete, modern shops we build and *deliver* what's needed in many fields. Our special Alloy Products Shop, for example, is equipped to produce medium and heavy stainless alloy and aluminum products for industry.

Building for land • Pressure vessels • Fractionating towers • Stills and tanks • Condensers and similar equipment • Special machinery • Plate work, etc.

Building for sea • Dry cargo ships • Tankers • Marine repairs • Dredges • Ferries • Marine engines • Marine machinery.

Sun Ship does a big job for many companies, and can do the same for you.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

"Torture tests prove W-K-M performance"

Continuous research and rigid testing give W-K-M customers constantly improved valves and fittings. In this test cell, for example, W-K-M products are tested far beyond calculated limits of endurance . . . even to complete destruction.

Specify W-K-M! You'll get superb quality and unmatched dependability. Write for literature on W-K-M products.

WRITE FOR CATALOGS LISTED

W-K-M

DIVISION OF ACF INDUSTRIES INCORPORATED

P. O. BOX 2117, HOUSTON, TEXAS

Products of W-K-M's *Creative Engineering*

W-K-M® Through-Conduit Gate Valves for Oilfield Services —Catalog 200

W-K-M's Pressure Sealing Gate Valves (ASA)—Catalog 1200

ACF non-lubricated Ball Valves— Catalog 1000

KEY-KAST® Alloy Welding Fittings— Quality Control Specifications 102958 and 103058

W-K-M Through-Conduit Gate Valves (ASA)—Catalog 300

ACF® lubricated Plug Valves—(Semi-Steel) Catalog 400, (Steel) Catalog 1100

KEY® Refinery Fittings and Return Bends— Bulletin KR-1257

5927

Construction Briefs

Continental Carbon Company will construct a $2,500,000 carbon black plant at Bakersfield, California, the first plant of its type on the West Coast. New facility, with annual capacity of 30,000,000 lb of carbon black, is scheduled for completion in mid- 1961. Products will be distributed through Witco Chemical Company, sole worldwide distributor of Continental Carbon Company's products.

Second major expansion of Continental Oil Company's Lake Charles, Louisiana, natural gasoline plant in six years will increase the plant's processing capacity from 100,000,000 to 150,000,000 cu ft of natural gas daily. Work on the project, slated to cost $2,000,000 will start in late June. Completion is scheduled for January 1961. In addition to boosting the plant's processing capacity 50 percent, the new unit will increase the Conoco facility's recovery of gas liquids, including ethane, from the processed natural gas stream.

A sulfur recovery plant will be built near Tilden, Texas by Trans-Jeff Chemical Corporation, new jointly-owned subsidiary of Transcontinental Gas Pipe Line Corporation and Jefferson Lake Sulfur Company. The plant, expected to go into operation within six months, will recover sulfur from the waste acid gas stream of Transco's gas treating plant at Tilden.

Extensive modernization of the DX Sunray Refinery at Duncan, Oklahoma, expected to cost $1,600,000, is underway. Program includes installation of a new steam generator and a complete turnaround of the catalytic cracking unit at a cost of $600,000; also a $1-million modernization of the gas recovery unit which produces propane-propylenes and butane-butylenes.

Sunray Mid-Continent will construct a $750,000 addition to its Criner gas products plant in McClain County, Oklahoma, which will up the plant's processing capacity to the vicinity of 27,000 to 30,000 Mcf per day of gas. Completion is expected by early summer.

New research laboratory and pilot plant for testing newly developed chemicals is being built by Armour Industrial Chemical Company, division of Armour & Company, adjacent to an existing Armour chemical plant in Chicago. Facility, expected to be ready for occupancy by late fall, will be used for applied research in fields of fatty acids and fatty acid derivatives.

A $900,000 expansion program is underway at two Gulf Coast division gas products plants of Sunray Mid-Continent. The **Carancahua Bay plant** in Jackson County, Texas, will be expanded at a cost of $400,000, doubling its capacity to 60,000 Mcf per day of gas. Expenditure of $500,000 at the **Benton plant,** Bossier Parish, Louisiana, will result in increased propane recovery and production of higher quality residual products.

Expansion of capacity in two basic industrial chemicals, methanol and formaldehyde, at its South Point, Ohio, plant has been announced by the Nitrogen Division, Allied Chemical Corporation. Methanol capacity will be hiked 50 percent and formaldehyde 35 percent.

An ethylene-glycol plant at Beaumont costing about $12,000,000 will be built by Houston Chemical, a wholly owned subsidiary of Chatham Chemical, New York. Site is adjacent to Mobil Oil's $25,000,000 ethylene facility, now under construction.

Onstream

Production of polyethylene film is underway at new Dow Chemical Company plants at Findlay, Ohio, and Fresno, California.

First commercial Hydrar unit for production of high purity cyclohexane from benzene has gone onstream at Gulf Oil Corporation's Port Arthur, Texas, refinery. Unit was designed by Universal Oil Products Company and built by Procon Incorporated.

A 9300 bbl per day delayed coking unit has been placed onstream at Mobil Oil Company's Torrance, California, refinery, giving the refinery a total coking capacity of 35,100 bbl per day.

New Northwest Petro-Chemical plant at Anacortes, Washington, is now in full operation. The $600,000 plant produces phenol, acrylic acid, and xylenol, primarily for the plywood resin market.

International Briefs

Largest catalytic reformer in Japan — a 6000 bbl per day Houdriformer unit — and an 8000 bbl per day hydrodesulfurization unit will be constructed at Mizushima, Japan, by Nippon Mining Company, Ltd. The 2000 bbl per day of desulfurized petroleum naphtha above that processed by the Houdriformer will be used for jet fuel blending and specialty naphthas. Houdry Process Corporation will supply catalysts for both units.

Stone & Webster Engineering Corporation will design and assist in engineering and construction of a second ethylene plant for Mitsubishi Petrochemical Company Ltd. at Yokkaichi, near Nagoya, Japan.

Columbian Carbon Co. will build a plant in the Toronto area for the manufacture of carbon black. It will go into production in 1961 with initial annual capacity of approximately 40,000,000 lb of oil furnace blacks.

Albatros Sulfuric Acid and Chemical Works, Vlaardingen, Holland, new company jointly owned by Albatros Superfosfaatfabrieken N. V., of Utrect, member of the Dutch Salt Group, and Cyprus Mines Corporation of Los Angeles, has announced plans for two plants and has awarded contracts for both to Chemical Construction (GB) Ltd. One plant will take sulfuric acid gas from pyrites, while the other will decompose sulfuric acid refinery sludge coming from an adjacent Shell Refinery.

Projected Dow Chemical of Canada plant at Fort Saskatchewan, Alberta, will be producing pentachlorophenol, ethylene oxide, ethylene glycols, and ethanolamines by late 1961.

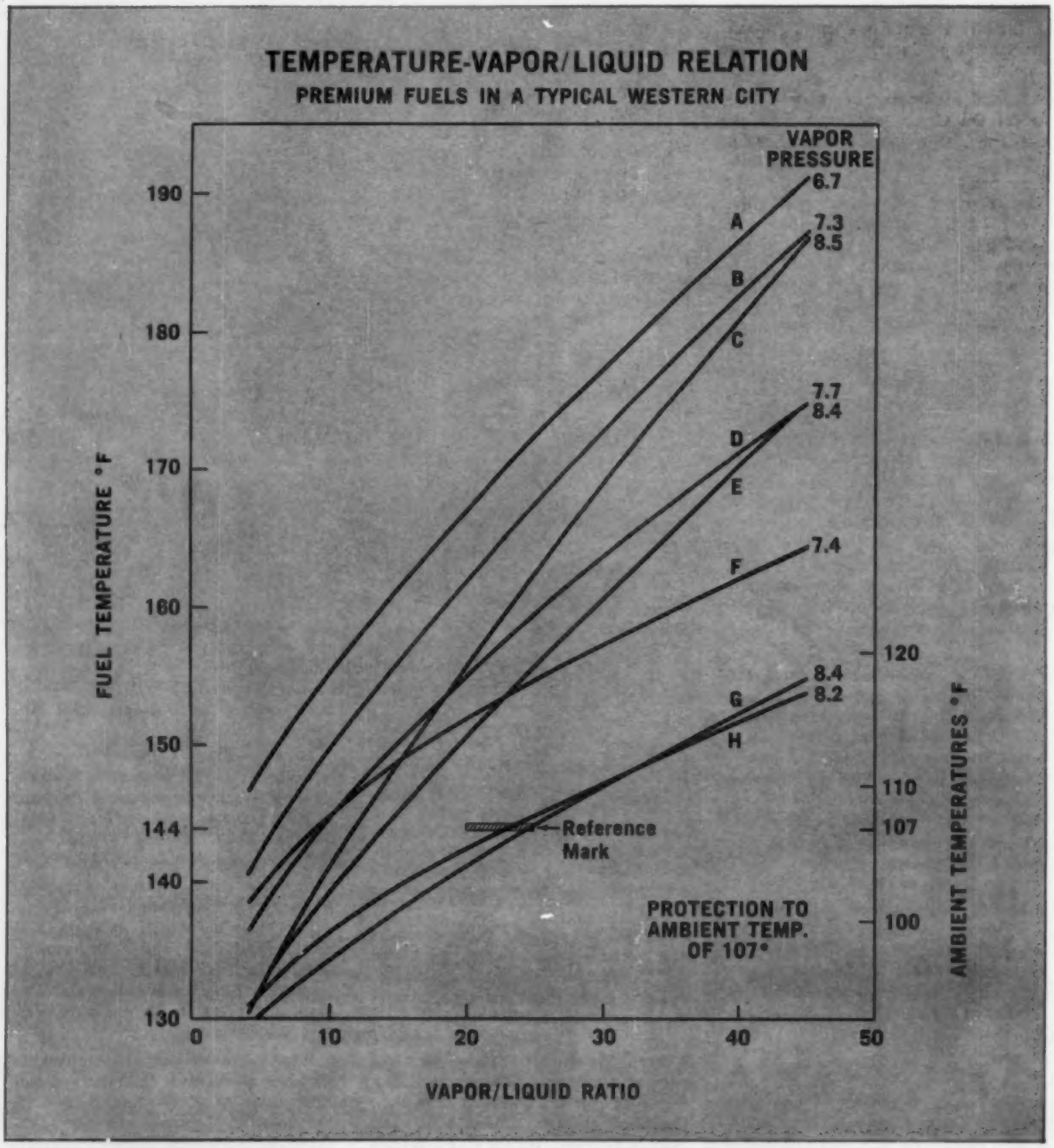
The C.S.R.C-Dow Pty. Ltd. plant at Altona, near Melbourne, Australia, will produce ethylene dichloride, caustic soda, and chlorine when a $3,375,000 expansion program is completed. The plant now produces styrene monomer.

Expansion of polyvinyl chloride facilities of the Ville La Salle Plant of Monsanto Canada, Ltd., will increase the plant's production by about 40 percent. Project will be completed within a year.

Here's a practical method for analyzing Front-End Volatility

Ethyl Research uses temperature-vapor liquid ratio curves to study relative and absolute front-end characteristics of gasoline

by **GILBERT WAY** — *Research Representative*



The above curves were calculated by the CRC method using Ethyl Volatility Survey data.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

WHERE TO SET front-end volatility for optimum balance of economic and automotive benefits is an important question for refiners.

One result of Ethyl's work in this field is a routine approach to interpretation and comparison of seasonal volatility data. The method can be used to establish or review volatility requirements at both the refinery and marketing levels. Data from the Ethyl Volatility Survey are used as the basis for temperature-V/L studies. *Refiners may have analyses of their own marketing areas upon request!*

Method is Simple; Easy to Understand

Temperature-V/L ratio curves—widely accepted as a graphic representation of how gasoline vaporizes in a fuel system—are used to show the volumes of vapor formed per volume of liquid at any given gasoline temperature. (Curves were calculated by the CRC method.)

In addition to showing relative vaporizing tendencies among various fuels, the curves may be related to reference points that indicate average conditions of fuel temperature and limiting V/L in automotive fuel systems. In the accompanying graph, average conditions for premium fuels are shown by the reference mark ranging from 20 to 25 V/L at a fuel temperature of 144°F.

This reference mark range was established from the results of extensive road tests conducted in recent years. Many factors were considered in arriving at this practical bench mark, such as severity of test conditions, age and condition of fuel system components, and variation of individual cars from average characteristics.

In theory, a fuel having a curve which passes through the reference mark would represent highest desirable use of front-end "fill." Those above the mark would be more conservative and those below subject to vapor lock.

The estimate of fuel temperature was established by adding the temperature rise at the fuel pump under severe vapor locking conditions and the ambient temperature to which protection against vapor lock is desired. Experience has shown that this fuel temperature rise at the pump averages 37°F. In the marketing area represented in the graph, protection is desired up to 107°F.

Some Interesting Observations on Volatility

The figure shows a wide variation in vaporizing tendency of fuels. Fuels A, B and C indicate a conservative position. This is contrasted by high volatility and border line protection against vapor lock by curves of fuels G and H.

Curves having steep slopes are typical of fuels pressurized by butane. Those with flat slopes indicate a high pentane content. Fuels C, E and G have essentially the same Rvp of 8.4 to 8.5. They converge at a V/L of 4, the V/L of the Reid vapor pressure bomb.

A V/L of 25, however, is reached by fuel G at a fuel temperature of 144°F., whereas fuel C must reach 163°F. before evolving the same quantity of vapor. Thus fuel C offers more protection against vapor lock than fuel G when abnormally high temperatures are encountered. This illustrates that, *for a given Rvp, butanized* fuels offer greater vapor lock protection in motor vehicles than fuels that are pressurized largely by pentane. Another way of comparing these two fuels is at constant temperature: at 150°F., fuel G has 35 V/L, fuel C only 16.

How Ethyl Research can help you

In addition to participating in Oil Industry cooperative studies, Ethyl Research has worked with many individual oil companies in studies of vapor locking tendencies of fuels and engines.

The experience gained in these programs provides a broad understanding of the problems associated with front-end volatility.

Our engineers are prepared to bring you analyses of Temperature-V/L characteristics of fuels from marketing areas of your choice, based on Ethyl Volatility Survey data. For overseas areas where Survey data are not available, studies can be made for refiners who supply sample inspection information.

If you would like this service, or more information about it, just contact your Ethyl Representative. He'll be glad to make arrangements.

ETHYL CORPORATION
New York 17, N. Y.

Ethyl Corporation of Canada Limited, Toronto
Ethyl USA (Export) New York 17, N. Y.

RESEARCH LABORATORIES—Ferndale 20, Detroit, Michigan • San Bernardino, California

A modern and versatile hydrocracking process . . .

Unicracking

R. C. HANSFORD C. P. REEG F. C. WOOD RAOUL VAELL
Union Oil Company of California

UNICRACKING is a new catalytic hydrocracking process, developed by Union Oil Company of California for the efficient and economical conversion of marginal or problem cracking stocks to high quality gasoline and middle distillate products. The process provides a new way to upgrade catalytic cycle oils, thermal and coker gas oils, and heavy cracked or straight-run naphthas. Even when the sulfur and nitrogen contents are high, Unicracking can effectively convert these stocks at a cost which is attractive in today's highly competitive economic climate.

For some time there has been a growing need for a process which can efficiently convert refractory gas oils and heavy naphthas which are unsuitable for catalytic reforming. It is well known that hydrocracking is capable of producing high yields of well refined light and middle distillates without the production of low-value fuel oil. This has been demonstrated earlier both in this country and abroad.[1,2,3,4] However, the high investment and operating costs of earlier hydrocracking processes have prevented their general use.

In spite of the development of improved catalysts having a more specific cracking activity than that exhibited by the early "hydrogenolysis" catalysts, hydrocracking processes operating in Europe during and after World War II still required thorough presaturation and refining of the feed to the hydrocracking step.[5,6] Both the pretreatment and hydrocracking stages required pressures in excess of about 3000 psig for continuous operation. Although the processes using the newer dual-function catalysts (hydrogenation and catalytic cracking activities) produced gasoline of higher knock rating than that of the gasoline produced with the old hydrogenolysis catalysts, they are still too expensive for today's economy.

In operation, Unicracking is similar to Unifining. Know-how gained in the many years of commercial experience in Unifining has been applied to the process.

Unicracking is based on several years of catalyst development and experimental process studies in small-scale equipment and in a 10 bbl per day pilot plant. In Fig. 1 is shown one of the small-scale experimental plant facilities used in advance research studies. In Fig. 2 is shown the 10 bbl per day pilot plant employed to obtain complete engineering data used in commercial unit design. This integral plant duplicates commercial operations in all important respects. The reactor assembly and associated piping for this plant are shown in Fig. 3.

FIG. 1. **Small-scale experimental unit** used in advanced research studies which led up to the development of Union Oil Company's new Unicracking process. It features a fixed-bed process which does not require frequent catalyst regeneration.

BASIS OF THE UNICRACKING PROCESS

The heart of Unicracking is a new catalyst which possesses a balance between hydrogenation and cracking activities. This results in high conversion and maximum selectivity in the production of desirable products. The production of dry gas and coke is negligible. The catalyst is rugged, both from the standpoint of repeated regenerations and of its tolerance toward sulfur and nitrogen compounds. Long life between regenerations and the ability to withstand repeated regenerations by conventional methods lead to low catalyst cost per barrel of feed processed.

The new dual-function catalyst makes possible many desirable reactions which occur only to a very limited extent in straight hydrogenation or in conventional catalytic cracking. Nevertheless, other reactions which are typical of these processes also occur very extensively. Thus, nearly complete desulfurization, denitrogenation, and olefin saturation are obtained in Unicracking.

In contrast to catalytic cracking, polycyclic aromatics such as methylnaphthalenes are easily converted by Unicracking. Here they are partially saturated and split to form high-octane monocyclic aromatics, naphthenes, and isoparaffins. For this reason, catalytic cycle oils, which are poor catalytic cracking feeds, are preferred feeds for Unicracking. Similarly, aromatic thermal gas oils, including coker gas oils, are good feeds for Unicracking. High-nitrogen stocks, which are difficult to convert in catalytic cracking because of nitrogen "poisoning," are efficiently converted by Unicracking. Also, high-sulfur feeds are converted to low-sulfur products.

An important feature of Unicracking is the production of gasoline in which the ratio of isoparaffins to normal paraffins is much greater than predicted by thermodynamic equilibrium. This is particularly true of the product obtained from highly aromatic or naphthenic gas oils.

Another important feature of Unicracking is that it produces naphtha of high cyclic content from high cyclic content feedstocks. This, plus the high iso-to-normal ratio of paraffins in the gasoline product, leads to the production of excellent reforming stocks from Unicracking of cycle oil, heavy catalytic gasoline, and other aromatic-naphthenic feedstocks.

Process Flow

Unicracking is a fixed-bed process which requires infrequent catalyst regeneration. The diagrammatic process flowsheet presented in Fig. 4 shows two stages of cracking. Untreated feed is introduced directly into the first-stage reaction system where 30 to 50 percent of feed is converted to gasoline. The reactor effluents from both stages are brought together and after appropriate cooling and liquid-gas separation the liquid enters a common fractionator. The uncon-

TABLE 1. Unicracking West Texas Fluid Catalytic Cycle Oil.

Feedstock	
Gravity, deg API	25.9
Distillation, D-158, deg F	
Initial	446
10%	468
30	483
50	498
70	516
90	544
Max	577
Sulfur, wt %	1.17
Nitrogen, ppm total	70
Hydrocarbon Analysis, wt %	
Paraffins	23
Olefins	7
Naphthenes	12
Aromatics	53
Heterocyclics	5
Yields	
Conversion, FF to 400 F EP Gasoline, vol %	90
Efficiencies, vol % FF converted	
C_4-400 F EP Gasoline	120.4
C_5-400 F EP Gasoline	105.9
C_7-400 F EP Gasoline	80.3
Yields	
Dry Gas, SCF/B FF	
C_1	1
C_2	11
C_3	65
Total Dry Gas	77
Liquid Product, vol % FF	
Isobutane	7.7
n-Butane	5.2
C_5-C_6	23.0
C_7-400 F	71.7
Diesel stock	10.7
Total Liquid Product, C_4-plus	118.3
Chemical Hydrogen Consumption, SCF/B FF[a]	2240

Product Quality	$C_5 - C_6$	C_7 – 400 F *Gasoline*	*Diesel Blend Stock*
Gravity, deg API	82.0	43.7	40.6
Octane Numbers			
F – 1 Clear	86.5	75.0	—
F – 1 + 3 ml TEL	98.5[b]	90.0	—
F – 2 Clear	82.0	69.0	—
F – 2 + 3 ml TEL	99.0	84.0	—
Hydrocarbon Analysis, vol %			
iso-paraffins	73	25	—
Paraffins	7		
Naphthenes	17	47	—
Aromatics	3	28	—
Distillation, D-86 or D-158, F			
Initial	95	224	556
10%	105	248	565
30	114	277	568
50	123	315	570
70	135	354	574
90	152	385	580
Max	168	400	630
Cetane Number	—	—	72
Sulfur, ppm	25	21	4
Nitrogen, ppm total	—	0.2	1.1
Pour Point, F	—	—	+40
Ramsbottom Carbon Residue on 10% bottoms, wt %	—	—	0.29
Color, ASTM D-1500	—	—	3.0

[a] Includes hydrogen used in chemical reactions and excludes solubility losses.

[b] This $C_5 - C_6$ fraction has a blending octane number of 99.5 F – 1 + 3 ml TEL in a typical premium.

verted oil is the feed to the second reaction stage and is recycled to meet fresh feed conversion requirements. In this second reaction stage the conversion to gasoline is 50 to 70 percent per pass. The production of a diesel blend stock as shown on the flow diagram is optional. This ability to produce two major products, gasoline and diesel, demonstrates the adaptability of the process to the refiner's ever-changing product requirements.

Two-stage cracking maximizes liquid yields and onstream periods between regeneration. This arrangement results in substantial savings in capital and operating costs over processing with separate feed pretreatment. It also minimizes reactor size for a given feed rate and reduces catalyst inventory.

Depending upon the feedstock and the process objective, reactor temperatures range from 600 F to 800 F and operating pressures vary from 500 psig to 2000 psig. These operating conditions allow the use of conventional refining equipment and mechanical design throughout the entire plant. The process is also simple to instrument and is readily adaptable to automatic control.

POTENTIAL APPLICATIONS

The process was developed primarily for the efficient conversion of refractory (aromatic) stocks and high-sulfur, high-nitrogen stocks to quality gasoline and middle distillate products. Optimum feed boiling range is usually about 400 to 600 F.

Developed applications showing favorable economics with reasonable product price structure are:

1. High gas oil conversion (90 to 100 percent) to gasoline. (Conversion is defined as the disappearance of feed.)
2. Intermediate gas oil conversion (50 to 80 percent) to gasoline with unconverted gas oil upgraded to high cetane premium diesel.
3. Conversion of heavy cracked naphtha for volatility and octane improvement.

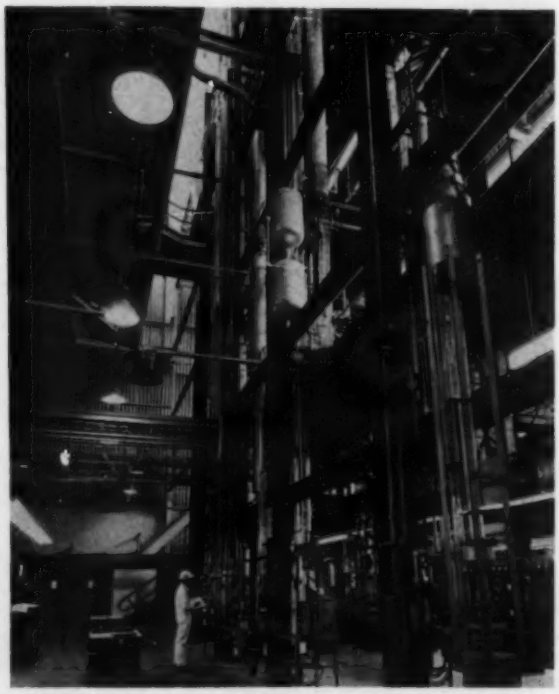


FIG. 2. 10 bbl per day Unicracking pilot plant.

The chemistry of the process suggests the following possible applications which may be of interest to some refiners:

4. Jet fuel production by reduction of boiling range and quality improvement.
5. Conversion of highly paraffinic naphthas to high octane light isoparaffins.

One of the basic objectives in developing the process was to reduce fuel oil production. This is accomplished by two mechanisms, namely, conversion of excess cutter stock or heating oil to gasoline and cracking to high conversion levels without producing fuel oil. The resulting higher yield of gasoline and premium mid-barrel at the expense of fuel oil permits reduction of refinery crude rate.

YIELD-QUALITY DATA ON TYPICAL FEEDSTOCKS

Unicracking Catalytic Cycle Oil

One of the principal feedstocks requiring the special features of Unicracking for conversion to gasoline is catalytic cycle oil. A light cycle oil produced in fluid cracking of stocks derived from West Texas crude is described in Table 1. This stock is typical of many produced by mid-continent refiners.

The yields and product quality data from Unicracking this aromatic catalytic cycle oil are also given in Table 1. C_4-400 F EP gasoline was produced at over 120 percent conversion efficiency. This efficiency is defined as the volume of gasoline produced per barrel of feed converted.

Unicracking California Delayed Coker Gas Oil

Coker gas oils are readily Unicracked to high-quality gasoline and mid-barrel products. The high-sulfur, high-nitrogen California coker gas oil described in Table 2 was Unicracked at 75, 85, and 100 percent conversions to 400 F end point gasoline. The three examples illustrate the processing flexibility of Unicracking for producing total gasoline or gasoline plus a premium mid-barrel stock.

Product quality data are given for the C_5-C_6 fraction and the C_7-400 F EP gasoline from Unicracking the coker gas

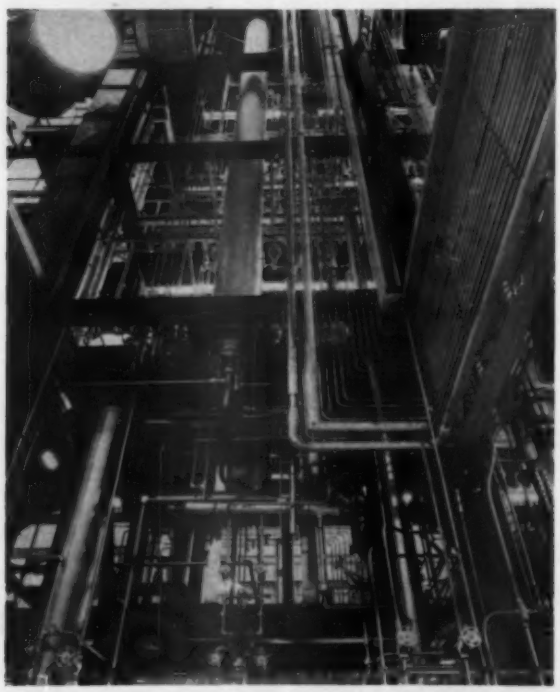


FIG. 3. 10 bbl per day pilot plant reactor system.

TABLE 2. Unicracking California Delayed Coker Gas Oil.

Feedstock			
Gravity, deg API	29.7		
Distillation, D-158, F			
Initial	390		
10%	447		
30	486		
50	511		
70	538		
90	570		
Max	600		
Sulfur, wt %	1.75		
Nitrogen, ppm total	1340		
Hydrocarbon Analysis, wt%			
Paraffins	17		
Olefins	11		
Naphthenes	29		
Aromatics	31		
Heterocyclics	12		
Yields			
Conversion, FF to 400 F EP Gasoline, vol %	*75*	*85*	*100*
Efficiencies, vol % converted FF			
C_4—400 F EP Gasoline	117.5	116.6	117.0
C_5—400 F EP Gasoline	104.9	103.3	102.2
C_7—400 F EP Gasoline	81.8	78.7	76.2
Yields			
Dry Gas, SCF/B FF			
C_1	2	2	3
C_2	9	10	12
C_3	46	53	67
Total Dry Gas	57	65	82
Liquid Product, vol % FF			
Isobutane	6.2	7.6	9.4
n-Butane	3.2	3.9	5.4
$C_5 - C_6$	17.4	21.1	26.0
C_7 – 400 F	61.4	67.7	76.2
Diesel stock	24.9	14.0	0.0
Total Liquid Product	113.1	114.3	117.0
Chemical Hydrogen Consumption, SCF/B FF[a]	1390	1510	1730

Product Quality (100 percent conversion)	$C_5 - C_6$	C_7 – 400 F *Gasoline*	*Diesel*[b] *Fuel*
Gravity, deg API	82.5	48.4	35.8
Distillation, D-158, F			
Initial	96	225	400
10%	109	251	430
30	116	276	470
50	125	307	510
70	138	344	550
90	155	383	580
Max	177	400	610
Octane Numbers			
F – 1 Clear	85.2	63.3	
F – 1 + 3 ml TEL	98.3	82.1	
F – 2 Clear	81.4	60.7	
F – 2 + 3 ml TEL	100.0	80.0	
Hydrocarbon Analysis, vol %			
Paraffins	73	31	
Naphthenes	24	54	
Aromatics	3	15	
Sulfur, ppm	5	1	30
Nitrogen, ppm total	—	0.4	4
Pour point, F			–5
Cetane number			56

[a] Includes hydrogen used for chemical reactions but excludes loss by solubility.

[b] Full-range diesel produced at 70 percent conversion.

TABLE 3. Reformability of Unicracked Gasoline From California Delayed Coker Gas Oil — Reformed at 500 Psig.

	Unicracked Gasoline-Reformer Feed C_7 to 385 F	*Reformed Gasoline Product $-C_5+$*
Yield, C_5+, vol % feed		83.5[a]
Yield, C_4, vol % reformer feed	—	7.2
Gravity, deg API	47.5	—
Distillation, D-86, F		
Initial	222	108
10	250	181
30	273	242
50	304	278
70	335	320
90	364	357
Max	384	446
Sulfur, ppm	15	nil
Nitrogen, ppm total	0.2	nil
Hydrocarbon Analysis, vol %		
n-Paraffins	6	29
Isoparaffins	23	
Naphthenes	49	8
Aromatics	22	63
Octane Numbers		
F – 1 Clear	66.0	96.8
F – 1 + 3 ml TEL	83.0	101.8
F – 2 Clear	61.8	83.0
F – 2 + 3 ml TEL	79.4	90.8

[a] Splitting the C_7 to 385 F full-range feed and reforming the light fraction at 275 psig and the heavy fraction at 500 psig results in a one percent yield improvement over the data shown.

oil at 100 percent conversion. As in the case of Unicracking catalytic cycle oil, the octane of the C_5-C_6 fraction is high, 98.3 F – 1 + 3 ml TEL and 100.0 F – 2 + 3 ml TEL.

Properties of the Unicracker gasoline before and after reforming are presented in Table 3.

The C_7-385 F EP gasoline from Unicracking the delayed coker gas oil was reformed to an octane rating of 101.8 F – 1 + 3 ml TEL at a C_5-plus yield of 83.5 volume percent. Because of its lower cyclic content, this naphtha reformed to a slightly lower yield than that obtained from catalytic cycle oil.

A highly olefinic, high-sulfur, 600 F EP fluid coker gas oil has also been Unicracked. In comparison with the delayed coker gas oil, the fluid coker gas oil showed a yield advantage of about two volume percent of feed, higher gasoline octanes, and higher hydrogen consumption. Other results are similar.

Unicracking Heavy Catalytic Gasoline

An attractive application of Unicracking is the upgrading of heavy catalytic naphtha from regular to premium grade blending stock. Increased volatility and improved quality may be attained without loss of total gasoline volume. The example shown in Table 4 illustrates the processing of a heavy catalytically cracked naphtha which is unsuitable for premium gasoline blend stock and too heavy for reforming. These data were obtained from once-through bench-scale operation. The C_7-335 F EP gasoline product from Unicracking was reformed and a typical yield-octane relationship is shown.

Cloyd P. Reeg, senior section leader at Union Oil Company of California's Research Center at Brea, California, is in charge of the bench-scale Catalytic Processing Section of the Refining Research Division. He has extensive experience and background in process design and development, pilot plant operation, data correlation, and process evaluation from 10 years' association with pilot plant activities. Major processing areas in which he has been engaged include Unifining, catalytic reforming, Unicracking, and shale retorting and refining. He received his bachelors degree in chemical engineering from Ohio State University in March 1948 and joined Union Oil Company immediately upon graduation. He holds several patents on Union Oil process developments.

Rowland Hansford, senior research associate with Union Oil Company of California, received his bachelors degree in chemistry from Davis and Elkins College in 1933 and his masters in chemistry from George Washington University in 1937. From 1933 to 1952 he was employed first by the E. I. du Pont de Nemours Company as a works chemist, and then by the Socony-Vacuum Oil Company as a research chemist and research associate. In 1952 he joined Union Oil Company of California as a research associate. He holds numerous patents on thermal and catalytic production of aromatics, cracking catalysts, reforming catalysts, desulfurization catalysts, hydrocracking catalysts, and petrochemicals. He is a member of the ACS and the AAAS, and in 1952 served as chairman of the Gordon Research Conference on Catalysis.

Raoul Vaell, project supervisor in the Process Engineering Division of the Research Department, Union Oil Company of California, received his bachelor's degree in chemical engineering from the University of Southern California. From 1945 until 1947 he was employed by the Chemical Division of B. F. Goodrich Company and by the Foster Wheeler Corporation. He joined the Union Oil Company in 1947 and held positions in the Manufacturing Department and pilot plant division of the Research Department before his present assignment. His responsibilities include supervision of commercial process design and evaluation of research projects. Major processes to which he has contributed during their developments are Unicracking, Unifining, Hyperflow, shale refining, and sand oil recovery and refining. He holds patents in these fields.

F. C. Wood, a supervisor in the Design Division of the Research Department, Union Oil Company of California, is in charge of pilot plant operations, including planning experimental programs and correlating plant data. His work for the past 12 years has been principally in the development of catalytic processes such as Unifining, Unicracking, and catalytic reforming. He also has done extensive work in chemicals, shale oil refining, distillation, and delayed coking. He holds several patents in the field of catalytic refining. He received his bachelor's degree in chemical engineering from Oregon State College and his masters in chemical engineering from the University of Wisconsin. He is a registered professional engineer in California and a member of the AIChE

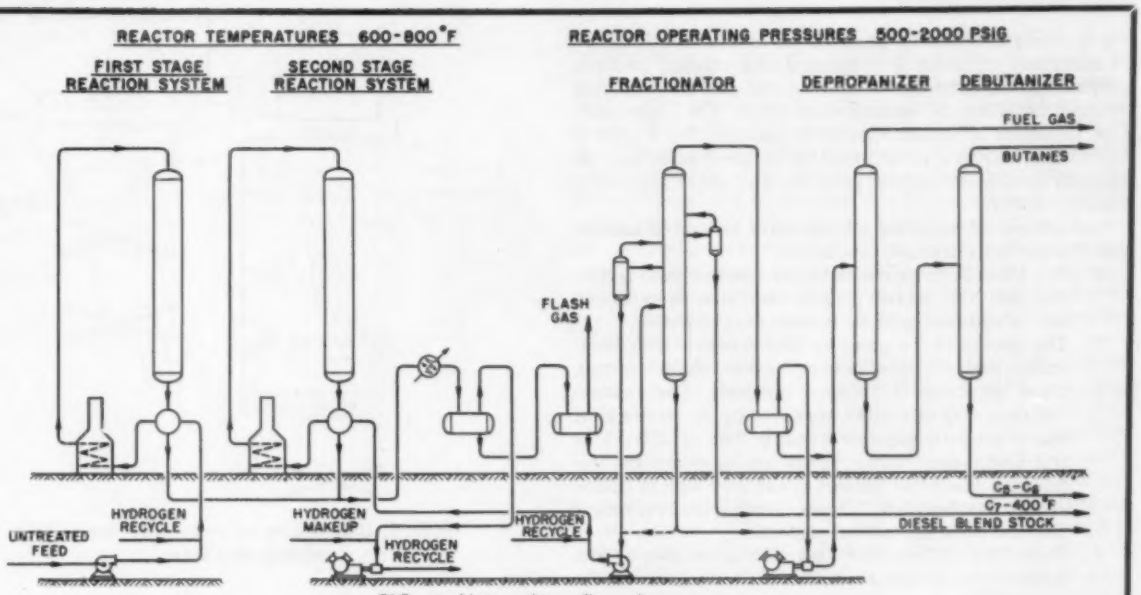


FIG. 4. Unicracking flow diagram.

CAPITAL INVESTMENT AND OPERATING COSTS

The Union Oil and C. F. Braun companies have prepared a definitive design and cost estimate of a 16,000 bbl per day Unicracker. This work served to optimize both process and mechanical design and to establish basic cost data.

Capital and operating costs for typical 5,000, 10,000, and 15,000 bbl per day units designed for conversion levels of 70 and 90 percent are shown in Table 5. These costs were estimated by C. F. Braun.

The total direct operating costs range from 23.9 cents per bbl for a 15,000 bbl per day plant at 70 percent conversion to 32.4 cents per bbl for a 5000 bbl per day plant operating at 90 percent conversion. Generally, capital and operating costs will decrease as the end point of the feedstock decreases or as the aromatic concentration of the feedstock decreases. The catalyst replacement cost is conservatively estimated at 5 to 6 cents per bbl.

REFINERY INTEGRATION

The economics of Unicracking for the refining situations investigated to date have been favorable from the standpoints of rate of return on investment and comparison with competitive schemes. The economics obviously depend on the objectives, existing refinery situation, product price structure and method of integration with existing facilities. Since these factors vary widely, each refiner's case must be considered separately.

The cracking of refractory, hydrogen-poor middle distillates is the application of most interest to refiners. The simplified block flow diagram in Fig. 5 shows how Unicracking could fit into a typical refinery to accomplish this objective.

In this application, the refractory aromatic stocks from the catalytic cracker, coker, and thermal cracking units, boiling from 400 to 600 F are fed to the Unicracker. The virgin gas oil, heavy coker and heavy visbreaker gas oils are fed to the existing cat cracker. Light oil thermal cracking is eliminated. The Unicracker and cat cracker complement each other through alkylation of the light olefins from the cat cracker with the isobutane from the Unicracker to maintain butane balance. For some size ratios of Unicrack-

TABLE 4. Unicracking Heavy Catalytic Gasoline.

Feedstock	
Gravity, deg API	33.2
Distillation, D-86, F	
Initial	358
10%	373
30	387
50	398
70	410
90	436
Max	467
Octane Ratings	
F – 1 Clear	86.0
F – 1 + 3 ml TEL	92.6
Sulfur, wt %	0.505
Nitrogen, wt % total	0.110
Hydrocarbon Analysis, vol %	
Paraffins	16
Naphthenes	11
Aromatics	54
Olefins	19

Product Quality	*Reformer Feed Unicracked Naphtha* $C_7 - 335$ F	*Reforming Data* C_5+
Yield, vol % reformer feed		
C_5-plus		90.0
Butanes		3.1
Gravity, deg API	44.8	
Octane Numbers		
F – 1 Clear	86.2	101.7
F – 1 + 3 ml TEL	93.8	104.1
Hydrocarbon Analysis, vol %		
n-Paraffins	8	21
Isoparaffins	16	
Naphthenes	37	3
Aromatics	39	76

ing to catalytic cracking, the need for butane isomerization or isobutane purchase is eliminated. An existing catalytic polymerization plant can usually be replaced by alkylation without installing an isomerization plant. The Unicracker C_3-C_6 fraction is blended directly to gasoline. The C_7-400 F Unicracker naphtha is reformed or in some cases may be blended directly to regular gasoline. The diesel fraction is blended directly.

Advantages of installing a Unicracker instead of another cat cracker for refractory stocks are:

1. The Unicracker produces higher gasoline yield and no fuel oil. This allows greater reduction in crude oil rate, if constant gasoline volume is an objective.
2. The quality of the gasoline pool is higher with lower sulfur and nitrogen content, lower olefin content, lower sensitivity and higher volatility. The gasoline volatility may be further improved by also feeding the heavy catalytic gasoline (boiling 380 to 470 F) to the Unicracker where yields are excellent on this fraction. Since this fraction is not very high in octane and is too heavy to reform, Unicracking-reforming also increases the octane potential.
3. From 10 to 50 percent high-quality diesel may be produced from low-cetane stocks by simply lowering the conversion.
4. The existing cat cracker efficiency (gasoline make over gas oil converted) is improved with the heavier feedstock resulting from adding the Unicracker.

SUMMARY

Unicracking fills the need for an efficient and economically attractive process for converting marginal or problem cracking stocks to gasoline and premium middle-distillate products.

It converts such stocks as refractory catalytic cycle oils, coker gas oils, and heavy cracked naphthas, much more efficiently than catalytic or thermal cracking. The yield of highly refined liquid products is generally in the range of 110-120 volume percent of feed.

The new process is capable of producing gasoline and premium diesel or jet fuels in varying proportions, as required by changing product demands.

Unicracking reduces the production of low-value fuel oil by converting fuel oil components to gasoline and middle-distillate products. An important feature of the process is that it produces no fuel oil fraction.

The light gasoline produced in Unicracking a variety of stocks is of excellent quality and can be blended directly to premium gasoline. The C_7-400 F naphtha from all stocks so far studied is a superior reforming stock because of high cyclic and isoparaffin contents. In some cases, this fraction can be blended into the regular pool.

The diesel fuel produced from coker gas oils or catalytic cycle oils has a cetane number of 55-70, depending on the stock and on the conversion.

Premium jet fuels can be produced without further treatment directly from paraffinic or moderately aromatic stocks.

Unicracking integrates very well into the refinery which already has catalytic cracking. Greater overall conversion efficiency will be realized by the refiner who processes his lighter gas-oil stocks in a Unicracker and his heavier stocks in the catalytic cracker.

The Unicracking process shows a very attractive payout because of its reasonable capital and operating costs and because of its excellent yield structure.

TABLE 5. Unicracking Capital and Operating Costs.

Unit Size, bbl per day	5,000	10,000	15,000	15,000
Conversion, vol % FF	90	90	90	70
Capital Investment of Boundary Limits Unit, Including First Catalyst Charge	$3,800,000	$6,400,000	$8,400,000	$7,200,000
Direct Operating Costs, cents/bbl feed				
Operating Labor	3.9	2.9	1.9	1.9
Fuel	7.4	7.4	7.4	6.1
Power	4.9	4.9	4.9	4.1
Cooling Water	1.3	1.3	1.3	1.0
Catalyst	5.9	5.9	5.9	5.1
Maintenance	9.0	7.6	6.7	5.7
Total Direct, cents/bbl	32.4	30.0	28.1	23.9

Basis for Operating Costs	*Dollars/Unit*
Operating Labor	90/opr/shift
Fuel	0.25/MM Btu
Power	0.007/KWH
Cooling water	0.015/M Gal
Maintenance 4% Investment/Year	

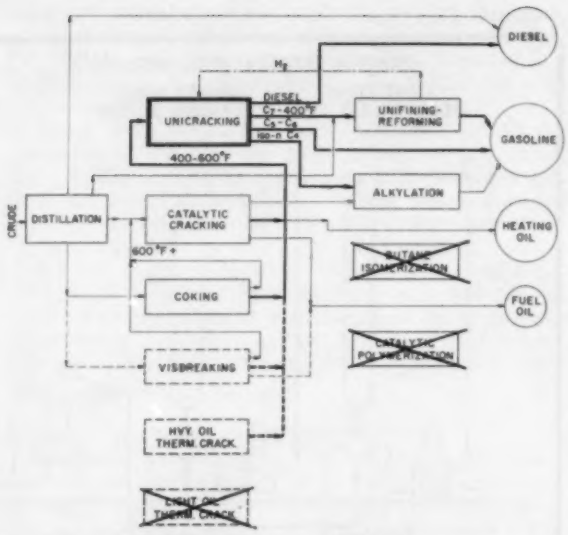


FIG. 5. Unicracking of refractory (aromatic) middle distillates.

ACKNOWLEDGMENT

The authors wish to thank the management of the Union Oil Research Department for permission to publish this paper, as well as to acknowledge their encouragement and guidance. Credit is also due the following people who have made important contributions to the development of the Unicracking process: W. I. Barnet, J. H. Duir, O. C. Eubank, H. C. Huffman, A. E. Kelley, N. D. Koch, B. Peralta, F. C. Price, A. J. Tulleners, D. A. Young, and others.

Adapted from a paper presented by the authors at the 48th annual meeting of the Western Petroleum Refiners Association in San Antonio, Texas, March 1960.

REFERENCES

1. W. J. Sweeney and A. Voorhies, *Ind. Eng. Chem.*, 26, 195 (1934).
2. C. L. Brown and E. J. Gohr, *Proc.* 2nd World Petroleum Congress, Paris (1937), Vol. II, page 281.
3. M. Pier, *Proc.* 4th World Petroleum Congress, Rome (1955), Sect. III, page 517.
4. H. Clough, *Ind. Eng. Chem.*, 49, 673 (1957).
5. H. H. Voge, G. M. Good, and B. S. Greensfelder, *Proc.* 3rd World Petroleum Congress, The Hague (1951), Sect. IV, pages 128 and 137.
6. R. L. Flanders, J. G. Girard, and B. D. Laughlin, Preprint 91, Fifty-second Annual Meeting, AIChE, San Francisco (1959). ★ ★ ★

DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas.**

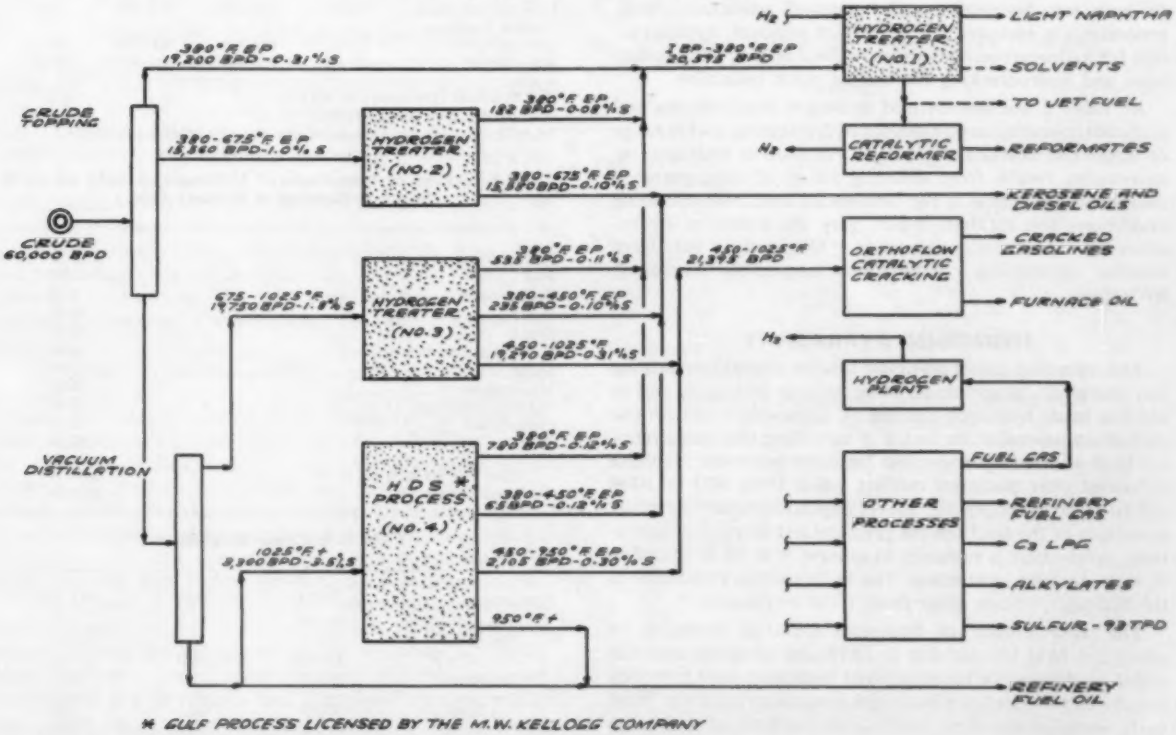
hydrogen processing . . . *in modern refining*

C. E. SLYNGSTAD AND F. L. LEMPERT
The M. W. Kellogg Company, New York, N. Y.

▸ A REFINER, when building or modernizing, faces two certainties: less low sulfur crude is available, and product specifications are increasingly difficult to meet.[1] Many crudes contain relatively high percentages of sulfur and other impurities in all fractions, and refining techniques which do not include hydrotreating will not yield competitive products. Further, one concludes from economic analyses of domestic situations that each barrel of crude should be converted to a high degree: the average demand for No. 6 fuel oil declined from about 29 percent on crude in 1945 to 16 percent in 1958, and the barrel demand for furnace oil has been relatively stable since 1956.[2] High conversion results in maximized use of catalytic and thermal processing to reduce distillate and residuum products with the consequential transfer of large amounts of crude oil impurities to all low boiling products.

The magnitude of the sulfur problem may be realized from the fact that about 10 MM tons of sulfur contained in crude oils is processed in refineries annually (derived by prorating the data of a previous survey to 1958 crude running rates[3,4]). Since catalytic reforming capacity is about 2.3 MM bbl per stm day, utilization of all by-product hydrogen for desulfurization, though impossible, would result in the removal of about 5 MM tons of sulfur annually. Table 1 lists sulfur contents of some typical crude oils, and often higher sulfur level is accompanied by larger amounts

FIG. 1. Hydrogen treating in a modern refinery.



of nitrogen, oxygen, metals, and sometimes hydrogen sulfide.[2,4,5] The effects of sulfur, nitrogen, oxygen and metals contents of crude or refined oil fractions may be summarized as:

Corrosion: Corrosion occurs from the well through crude storage, in refining operations, in product storage, in combustion engines and in fuel-using systems.[6,7,8,9,10,11,12] The average cost of corrosion in refinery operations alone has been estimated at 9 cents per bbl of crude processed.[6]

Operations: Operating problems are created through plugging of catalyst beds, poisoning of alkylation, polymerization, isomerization, reforming, and cracking catalysts, foaming in amine and caustic systems, and turn-around problems of safety and cleaning.[3,13,14,15]

Product use: The problems of product odors, color and gum stability, gasoline haze, fuel oil stability and burning qualities, and lubricating oil life are well known.[8,11,16,17,18,19,20,21,22]

TEL effectiveness: The role of gasoline sulfur content has been discussed by Sittig and Unzelman.[3] The removal of all sulfur from gasoline could decrease the use of TEL to 50 percent of its present volume,[23] now valued in U. S. gasolines at about 10 cents per bbl crude throughput.[23a]

Atmospheric pollution: The emission of large quantities of sulfur oxides to the atmosphere from industrial or automotive sources will not be tolerated indefinitely, and is leading to stringent pollution control laws.

Processing of crudes can be facilitated and simplified by proper application of hydrogen processing which can result in decreased refinery corrosion, increased catalyst selectivities and lives, markedly improved product qualities, and conversion of sulfur and other impurities to compounds removable from refinery process or waste streams. The term "Hydrogen Treating" as utilized in this paper refers to both non-destructive and "creative" variations: thus, processes are included for impurities removal, hydrogenation for hydrocarbon conversion without boiling point reduction, and hydrocracking for boiling point reduction.

In Table 2 are summarized hydrogen requirements and probable operating conditions for hydrotreating a wide range of virgin and cracked stocks. The variation in hydrogen requirements results from differing ratios of mercaptans to thiophenes to sulfides in the feed stocks, and from operating conditions and catalysts which vary the extent of hydrocracking and aromatics saturation.[15] Obviously, a very large number of refining combinations is possible employing hydrogen.

HYDROGEN AVAILABILITY

The increased use of platinum catalyst naphtha reforming has provided a large volume of by-product hydrogen, and its use has made hydrogen treating an economical tool for the petroleum processor. In fact, it is surprising that some refiners have allowed hydrogen use for other purposes. Naphtha reformed over platinum catalyst yields from 400 to 1000 std cu ft of hydrogen per barrel depending upon the characteristics of the feed and the pressure and severity of operation: production is sufficient to remove 8 to 20 lb of sulfur in hydrotreating operations. The hydrocarbon impurities in the hydrogen stream range from 10 to 30 percent.

The rapid growth of hydrogen treating capacity to about 2.3 MM bbl per day in 1959 and advances made in reducing the cost of manufactured hydrogen have provided incentives for continued hydrogen processing research. Most early installations were justified as methods of corrosion and contamination control in platinum reforming, and, subsequently, units were added to improve the qualities of other products. However, hydrogen treating catalytic feedstocks may markedly improve process selectivity and yields, eliminate the need for treating product streams, and justify the installation of hydrogen manufacturing facilities. Thus, processes such as steam reforming and partial oxidation are considered secondary sources of hydrogen. A typical cost breakdown for manufacturing hydrogen by steam reforming of refinery gas is shown in Table 3 (5 MM std cu ft per day), and costs of other methods have been summarized elsewhere.[24]

CATALYSTS AND PROCESSES

The intense interest in hydrotreating is indicated by the fact that at least 15 manufacturers formulate about 20

TABLE 1. Typical Sulfur Contents of World Crudes.

Crude Source	Average Sulfur Content, Wt. %	% of Bbl >1.0% S
North America	1.0	20-30
West Texas	1.37	
California	1.05	
East Texas	0.26	
Coastal	0.19	
South America	1.8	70-75
Venezuela	1.36	
Middle East	1.60	95-100
Kuwait	2.50	
Arabian	1.68	

TABLE 2. Hydrogen Treating Process Conditions.

Virgin Fractions	Hydrogen Required[3] CF/#S Removed	Operating Conditions Range PSIG	F	V/Hr./V
Whole Crude[1]	50-75	900-2500	750-900	0.25-2.0
IBP—675 F[2]	25-60	400-800	600-750	2-7
675—1050 F[2]	40-80	600-1500	650-800	1-3
Lube oils and waxes	30-60	300-1000	600-750	1-4
Cracked Fractions				
IBP—675 F[2]	30-75	100-900	500-750	2-10
400—1000 F[2]	40-75	600-900	650-800	1-3

[1]Or residual fractions therefrom.
[2]Or contiguous parts thereof.
[3]Add 7-14 cu ft per lb equivalent mono-olefins saturated.

TABLE 3. Cost of Manufactured Hydrogen, $/MM std cu ft Steam Reforming of Refinery Gas.

Raw material	$ 79.20
Fuel	61.80
Cooling water	9.64
Power	34.00
Steam	36.00
Catalyst and chemicals	14.40
Labor	27.00
Maintenance	25.00
Taxes and insurance	12.50
Depreciation	62.50
Interest	37.00
Total cost per MM std cu ft	$398.54
Total cost per ton	$152.00

TABLE 4. Crude Breakdown.

Component	BPSD	°API	Wt. %S
IBP—380 F	19,200	61.3	0.31
380—675 F	15,650	37.0	1.0
675—1025 F	19,750	20.0	1.8
Residuum	5,400	8.1	3.5
Total	60,000	34.5	1.37

cobalt molybdate catalysts. Other hydrogen treating catalysts are also produced. The many cobalt molybdate catalysts differ somewhat in catalytic properties, but purchasers have been confused through not recognizing effects of metals contents (price) and particle size.[25]

At least 10 processes are offered to the petroleum industry at royalties from none to $38 per daily barrel. The statistics for M. W. Kellogg Company designed[26] hydrotreaters are summarized here since they have not appeared previously:

	No. of Units	Total BPSD
Reformer feed* hydrotreaters	16	157,000
Distillate hydrotreaters	13	165,000
Total	29	322,000

*Or gasoline

HYPOTHETICAL REFINERY FLOWSHEET

A discussion of potential applications of hydrogen treating in a modern refinery is facilitated by the block flow diagram of a hypothetical 60,000 bbl per stm day refinery processing average high sulfur West Texas crudes. Coking is not included in the refinery plan since the resulting high sulfur coke would have insecure marketing potentialities, and only sufficient No. 6 fuel oil is produced to balance refinery fuel requirements, i.e., no sales of heavy fuel are contemplated. Fig. 1 shows the flow through crude topping, vacuum flashing, *four hydrotreaters*, catalytic reforming, and ORTHOFLOW fluid catalytic cracking. The refinery would also include such processing as gas recovery, alkylation, isomerization and sulfur production, but these processes are not concerned directly with hydrogen treating. The crude breakdown for various basic streams is presented in Table 4.

Placement of the four hydrogen treaters is shown in Fig. 1 together with hydrogen manufacturing which usually will be required when treating both catalytic cracking feedstock and vacuum unit bottoms. The advantages for each of the treaters will be discussed individually.

HYDROGEN TREATING GASOLINES

Hydrogen treating 380 F E.P. gasolines from crude and treaters 2, 3 and 4 results in elimination of a light naphtha mercaptan treater. Generally, total raw gasolines will contain from 0.03 to 0.6 wt. percent sulfur, and sometimes small quantities of metals such as arsenic, copper and lead, and 0-30 parts per million of organic nitrogen compounds. Sulfur, metals and nitrogen compounds act as poisons to platinum reformer catalysts, and will cause temporary or permanent loss of catalyst activity and selectivity. Also, without pretreatment the sulfur in the reformer feed will be converted to hydrogen sulfide by the reforming catalyst with resultant corrosion of inadequate alloys and catalyst bed plugging.

The cobalt molybdate catalysts employed in hydrogen treating units will convert sulfur compounds to hydrogen sulfide and nitrogen compounds to ammonia; the latter are removed from the treater effluent. Olefins will be saturated by hydrogen and eliminated as potential reformer coke-formers. The metals compounds are decomposed and the metals adsorbed by the treater catalyst. They cause no decline in the activity of the cobalt molybdate catalyst, but the catalyst is discarded after saturation with metals since the impurities will then pass to the platinum reformer catalyst.

Typical feed stock and product inspections for hydrotreater operations are shown in Table 5. If nitrogen-containing stocks are processed higher pressures (700-900 psig) and low space velocities are used. Platinum reformer feed stocks should contain less than 0.005 percent sulfur and 2 ppm nitrogen, and essentially no metals or olefins.

In the contemplated refinery (Fig. 1) combined 380 F end point gasolines from crude topping and hydrogen treaters 2, 3 and 4 are treated at conditions such that the finished light and heavy naphthas contain, respectively, 0.001 and 0.003 percent sulfur.

TREATING MIDDLE DISTILLATES

In the subject refinery, the virgin 380-675 deg E.P. fraction (burner oils) is processed in hydro-treater No. 2, typical results for treating such fractions being presented in Table 6. Specifications for these fuels and jet and diesel oils are increasingly more stringent, with emphasis on sulfur contents, burning characteristics, and storage stability.

Kerosine hydrotreating results show that high sulfur, high odor, poor color material is converted to a white, doctor-sweet product with markedly reduced wick char and low sulfur content. Sludge formers in diesel oils are objectionable since they necessitate frequent cleaning of tanks, filters and related equipment. Hydrogen treating of diesel and furnace fuels yields products with low sulfur content; sludge formation is minimized and burning char-

TABLE 5. Hydrogen Treating of Catalytic Reformer Feedstocks.

Feedstock	West Texas Straight-run Naphtha		California Virgin-Cracked Blend		Mid-Continent Thermal Naphtha	
	Charge	Prod.	Charge	Prod.	Charge	Prod.
Gravity, °API	51.9	52.0	48.4	51.0	53.5	
ASTM Distillation						
IBP	200	198	194	200	225	
10%	244	244	240	237	244	
50%	278	278	297	294	290	
90%	312	314	376	370	356	
FBP	331	331	419	423	398	
Sulfur, Wt. %	0.14	0.003	0.79	0.005	0.10	0.0005
Nitrogen, ppm	—	—	134	0.5	65	1.2
Bromine No.	—	—	49	0.6	—	—

TABLE 6. Hydrogen Treating Middle Distillates.

Feedstock	West Texas Kerosine		Light Diesel		Heavy Diesel or Furnace Oil	
	Charge	Prod.	Charge	Prod.	Charge	Prod.
Gravity, °API	40.2	41.3	40.3	41.4	33.1	36.2
ASTM Distillation						
IBP	364	360	336	360	374	304
10%	397	394	380	386	448	425
50%	440	436	438	436	530	514
90%	508	505	542	540	612	610
FBP	548	552	600	600	668	654
Sulfur—Wt. %	0.53	0.03	0.66	0.03	1.40	0.10
Color—Saybolt	5	25	—	25		
NPA			1¾	—		
Cetane index	46	48			46	51

TABLE 7. Hydrogen Treating Cracking Feed and Recycle Stocks.

Inspections and Analyses	California Gas Oil		Mid-Continent Recycle Oil	
	Feed	Product	Feed	Product
Gravity—°API	21.6	25.6	27.6	30.6
ASTM distillation				
IBP—F	398	448	330	264
10%	554	560	560	539
50%	758	743	610	596
90%	908	890	659	647
EP—F	993	970	716	704
Aniline point—F	143	174	154	155
Sulfur—Wt. %	1.42	0.07	0.40	0.07
Total nitrogen—Wt. %	0.30	0.05	—	—
Conradson carbon—Wt. %	0.18	0.004	—	—

acteristics improved. The need for the use of additives is essentially eliminated.

The refinery schematically described in Fig. 1 is capable of producing kerosine or jet fuels containing less than 0.05 percent sulfur and diesel oil containing less than 0.15 percent sulfur. The total production of such products could be about 16,000 bbl per stm day.

TREATING CRACKING FEEDS, RECYCLE AND PRODUCT STREAMS

Untreated gas oil feeds to catalytic cracking units often contain high percentages of sulfur, oxygen and nitrogen compounds, and cracked products from either high or low sulfur stocks contain significant concentrations of sulfur and phenolic compounds. About 5 percent of the sulfur fed appears in the debutanized cracked gasoline, and produced hydrogen cyanide can lead to equipment hydrogen attack. Hydrogen processing (treating and hydrogenation) of feed stocks will markedly decrease sulfur, nitrogen, Conradson carbon, metals and olefin contents, and convert significant percentages of polyaromatics to monoaromatics.

Polyaromatics are refractory compounds and tend to form large amounts of coke and gas when cracked, and may crack to fewer ringed compounds in the cycle oil boiling range. Obviously, it is desirable to maximize the monoaromatic and naphthene contents of cracking unit feeds. Data for some results of hydrogen treating are presented in Tables 7 and 8 and plotted in Fig. 2 and 3.

Hydrotreated stocks yield higher gasoline and lower coke yields when cracked: the gasoline to coke ratio is increased by a factor of 1.2-2.0 as a result of polyaromatics saturation and sulfur and nitrogen removal. The latest design ORTHO-FLOW fluid catalytic cracking unit would enhance this factor further. The cracked gasoline from treated feed has somewhat higher clear octane numbers, greater TEL response and improved oxidation stability. Cracking unit investment is decreased since alloy and regeneration requirements are less, and atmospheric pollution with sulfur oxides is decreased.

The reasons for the choice of cracking feed rather than cracking unit recycle stream and/or products hydrogen treatment in the refinery (Fig. 1) are summarized:

1. Minimize number of refinery treaters, types of catalysts, and chemicals,
2. Reduce cracking unit investment,
3. Provide additional metals protection for the cracking catalyst,
4. Increase butane-butylene feed to sulfuric acid alkylation,

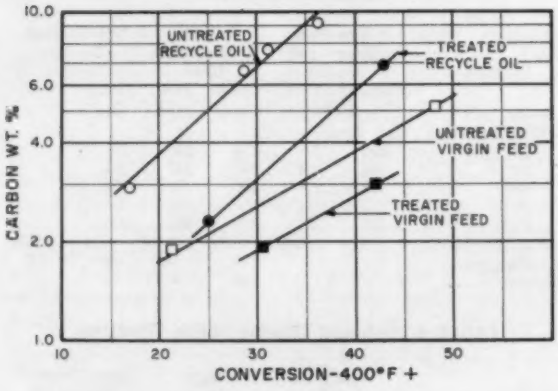


FIG. 2. Effect of hydrogen treating on catalytic carbon yields.

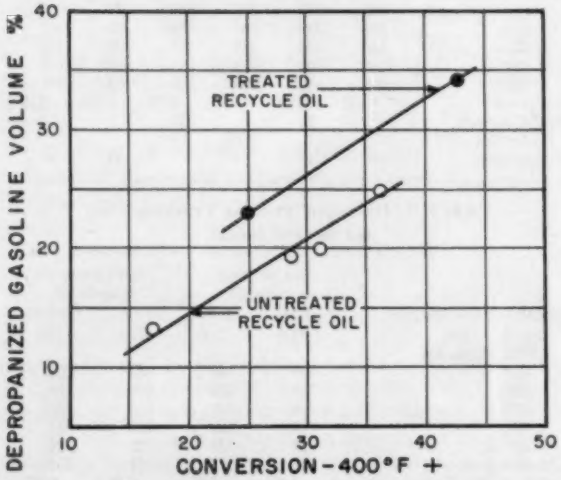


FIG. 3. Effect of hydrogen treating on catalytic gasoline yields.

TABLE 8. Hydrogen Treating Cracking Feed.[30]

	West Texas Gas Oil		
		Product	
Feed	Feed	Mild	Severe
Inspections and Analyses			
Gravity—°API	25.5	28.4	29.9
Sulfur—wt. %	1.68	0.12	0.05
Nitrogen—wt. %	0.13	0.05	0.02
Monoaromatics*	67	81	78
Polyaromatics*	59	31	16
Processing Conditions			
Pressure—psi	—	750	1500
H_2 consumed—SCFB	—	350	530

*Millimoles/100g.

TABLE 8A. Yields from Cracking Untreated and Treated Feeds.[30]

Feed (See Table 7)	West Texas Gas Oil	
	Raw	Severe Treated
Yields—weight %		
Conversion	55	
C_2 and ltr	4.9	2.6
Propanes	5.8	5.6
Butanes	5.8	7.8
Gasoline	33.0	37.2
Light cycle oil	25.0	27.0
Heavy cycle oil	20.0	18.0
Coke	5.5	1.8
Inspections		*
Gasoline		
Sulfur—wt. %	0.18	0.01
F-1+3cc TEL	98.0	99.6
F-2 clear	84.1	86.0
Light cycle oil		
Gravity—°API	21.4	25.6
Sulfur—wt. %	1.5	0.12
Diesel index	22	30
Heavy cycle oil		
Gravity—°API	15.1	22.2
Sulfur—wt. %	1.4	0.34

*From intermediate severity hydrotreated product.

5. Increase cracked gasoline yield and octane numbers, and
6. Decrease catalyst make-up rate to ORTHOFLOW fluid unit.

However, a discussion of recycle and products treating will present an alternative approach. Objectives in upgrading gasolines include reduction of sulfur, diolefin, and nitrogen contents. Feed stock boiling range, treating conditions and catalysts are chosen which minimize saturation of mono-olefins to avoid a marked loss in product leaded octane numbers. In general, the conditions include low pressures, low temperatures and total gas rates, and relatively high space velocities. Treatment at these conditions can produce noticeable improvements in sulfur and diolefin levels, but nitrogen content is relatively unchanged. Table 9 presents results of cracked naphtha treating. It may be noted that considerable quality improvement may be effected while maintaining product leaded octane numbers. An alternative gasoline treater utilizing sodium might be considered.[21a]

The objectives in upgrading cracked furnace oils are the same as those previously discussed for middle distillates, although more severe processing conditions will usually be employed. Table 10 shows the results of treating both a catalytically cracked furnace oil, and a blend of catalytically cracked and coker gas oils. The products from these experiments would meet present specifications but increased treater severity should be provided for future operations at product sulfur contents of about 0.1 percent.

HYDROGEN TREATING RESIDUUM

A hydrogen treater (hydrocracking) has been provided for residuum in excess of refinery fuel requirements (Fig. 1) to avoid problems of coke or residual disposal, since markets are often soft for both No. 6 fuel oil and high sulfur coke. The HDS process* will provide excellent quality feeds for reforming and ORTHOFLOW fluid catalytic cracking, and release residuum cutter stock for sale as No. 2 furnace oil, some results being summarized in Table 11.

Utilizing data from a study presented by McAfee, et al,[24] the price of reformer and cracking feeds derived from HDS processing does not exceed $1.50 per bbl when No. 6 fuel oil derived from vacuum residuum is selling for $1.50 per bbl. That is, the available margin when processing the oils in cracking and reforming units is $1.00-1.25 per bbl greater than for crude-contained fractions. The hydrogen requirements for HDS based on absolute sulfur removal are only slightly higher than for vacuum distillate treater No. 3.

REFINERY HYDROGEN BALANCE

The hydrogen requirements for chemical reactions in the four hydrogen treaters of the hypothetical refinery will vary from 25 to 75 std cu ft per lb of sulfur removed. Theoretically, the hydrogen variation for sulfur reactions is 12 to 48 std cu ft per lb of sulfur removed. The actual requirements are as follows:

	SCFD
Hydrogen Treater No. 1	275,000
Hydrogen Treater No. 2	1,665,000
Hydrogen Treater No. 3	5,800,000
Hydrogen Treater No. 4	2,770,000
Total	10,510,000

Additionally, allowance for fractionation losses should be about 10 percent.

The quantity of reformer feed available is 13,090 bbl per stm day, and can be expected to produce about 10.5 MM std cu ft per day of hydrogen at a reformate octane number of 95. However, allowance must be made for the production of jet fuels and solvents, and for decreased hydrogen production at the end of reformer catalyst life.

Therefore, the hydrogen manufacturing plant is sized as:

Requirements — Chemical	10.51 MM SCFD
Fractionation	1.05
Future	1.05
	12.61
Available (reformer less 10%)	−9.45
Hydrogen plant	3.16 MM SCFD

TABLE 9. Upgrading of Cracked Naphthas.

Feed	Catalytic Naphtha[23]		Heavy Catalytic Naphtha	
	Feed	Prod.	Feed	Prod.
Boiling Range, F	200-350		278-402	
Inspections				
Sulfur—wt. %	0.18	0.02	0.34	0.17
Bromine number	71.0	33.0	68.8	53.5
F-1 clear	88.9	85.9	87.9	86.4
+ 2 cc TEL	94.2	93.2	—	—
+3 cc TEL	—	—	93.2	93.5
F-2 clear	77.5	77.5	—	—
+2 cc TEL	83.3	83.3	—	—
Breakdown*—Min	75	375	—	—
G. M. Gum*	15.0	2.0	—	—
Nitrogen			137	111

*Inhibited

TABLE 10. Hydrogen Treating of Cracked Furnace Oils.

Feed	Cat. Cracked Furnace Oil		Blend of Cat. Cracked Plus Coker Furnace Oil[23]		
	Feed	Prod.	Coker Feed	Cat. Feed	Prod.
Gravity—°API	26.6	30.3	27.5	18.0	—
Volume percent	—	—	20.0	80.0	—
ASTM Distillation					
IBP, F	430	386	400	440	—
10%	480	460	475	485	—
50%	534	526	530	540	—
90%	596	596	600	600	—
FBP	628	628	640	650	—
Sulfur, wt. %	2.17	0.21	4.00	3.90	0.50
Color—NPA	2—	1½—	—	—	—
Stability, 210 F, 40 hr					
Insolubles mg/100 grams	117	1.6	—	—	—

TABLE 11. HDS Processing* Kuwait Reduced Crude.[21,24]

Feed Stock	17% Reduced Crude		71% Reduced Crude 29% Lt. Cycle Oil	
Gravity—°API	5.8		10.7	
Sulfur—wt. %	5.5		4.9	
Product yields and sulfur contents	Yield	% S	Yield	% S
Dry gas	6.4	—	5.2	—
Debut. 300 F EP gasoline	14.9	0.1	16.0	0.22
300-400 F naphtha	11.0	0.03	12.6	0.04
410-670 F furnace Oil	41.4	0.16	46.5	0.29
670-950 F FCC feed	27.3	0.42	20.3	0.81
Bottoms	4.1	3.7	3.0	2.5
Dry gas yields as wt. %, others as vol. %				

*Gulf Oil Corporation Process Licensed by The M. W. Kellogg Company.

REFINERY VARIABILITY

The refinery outlined in Fig. 1 will provide a gasoline to distillate ratio of about 1.75 to 1. This ratio may be decreased to about 1.45 to 1 by diverting propylene from alkylation to LPG and reducing the cracking unit conversion such that maximum end point No. 2 furnace oil is produced. Product sulfur contents would be uniformly low as summarized:

	% S
Light naphtha	0.001
Catalytic reformate	0.002
Cracked gasoline	0.04
Kerosine + diesel	0.10
No. 2 furnace	0.25

The total gasoline from the refinery would contain less than 0.015 percent sulfur and requirements for tetraethyllead and inhibitors would be less than for alternative processing methods.

The elimination of No. 2 furnace oil production through hydrogen treating would increase the gasoline to distillate ratio to about 2.5 to 1. These hydrogen treating processes, operating similarly to those described, will reduce furnace oil to butanes, light naphtha and reformer feed components. The hydrogen plant size would be increased markedly, of course.

HYDROTREATING ECONOMICS

Hydrogen Treater No. 1: Hydrotreating catalytic reformer feeds has an adequate payout when credits for increased reformer catalyst life, average gasoline yield, and decreased corrosion and maintenance are included in an economic balance. Therefore, hydrotreater No. 1 capacity is greater than normal by the quantity of light naphtha. However, the investment cost for the incremental capacity is slightly less than for a mercaptan removal treater. Operating costs for a mercaptan treater, including incremental labor, chemicals and TEL, are greater than for hydrotreating, and an additional refinery battery would be required.

Hydrogen Treater No. 2: The treater for 380-675 F fractions is incorporated to upgrade No. 1 and 2 burner oils to higher quality products, including jet fuels. The profitability for this operation is about 27 cents per bbl if the differential between the feed and products is 1 cent per gal. A large economic incentive exists, therefore, to treat these stocks.

Hydrogen Treater No. 3: The effectiveness of cracking unit feed treating is obvious from the following comparison of alternative hydrogen treating applications to a catalytic cracker to obtain equivalent gasoline and furnace oil sulfur contents:

	Fig. 1	Alt. No. 1	Alt. No. 2
Feed treating	Yes	No	No
Light catalytic naphtha treating	No	No	Yes
Heavy catalytic naphtha treating	No	Yes	Yes
Furnace oil treating	No	Yes	Yes
Recycle oil treating	No	Yes	No

Three treaters are required in either alternate to yield products with the same sulfur contents as for the feed treating case of Fig. 1, but the gasoline octane numbers are lower with either alternate. The investment for feed treating is less than for alternate 1 but more than for alternate 2. The increased investment over No. 2 has a payout of about 3 months based only on improved ORTHOFLOW fluid cracking unit yields. Of course, octane number increases and operating labor reductions would improve the payout further.

Hydrogen Treater No. 4: The cash returns on investment for the HDS unit are 61 and 33 percent when No. 6 fuel oil is selling for $1.50 and $2.00 per bbl, respectively. Assumptions were that furnace oil is priced at $3.36 per bbl and all HDS operating costs total 75 cents per bbl.[34] The operating costs included in reference [34] have been reanalyzed, and are believed to be higher than might be expected. Product values assumed were naphthas at $3.78 per bbl and ORTHOFLOW fluid cracking feed at $2.75 per bbl.

SUMMARY

Hydrogen processing is applicable in modern refining to reduce the number of treating processes, to provide feed stocks which improve processing yields and decrease catalyst usage, and to eliminate either coke or No. 6 fuel oil marketing problems. Further, hydrogen processing will reduce pollution and corrosion both in the refinery and in the areas of product usage.

The economics of hydrogen treating lighter boiling streams are excellent, while those for heavier boiling streams depend on feed stock properties, product quality requirements, and sales potential for products derived from the "bottom of the barrel." ★ ★ ★

References and Bibliography

1. Kellogg ram, 1954 Series, No. 2.
2. Guthrie, V. B., *World Petroleum*, June 1959, p. 134-142.
3. Sittig, M. and Unzelman, G. H., *Pet. Proc.*, Aug. 1956, p. 75-95.
4. Tait, T., "Progress in Petroleum Technology," Advances in Chemistry Series, Wash, D. C., ACS (1951).
5. Nelson, W. L., *Oil & Gas Journal*, Jan. 3, 1955, p. 116-117.
6. *Pet. Proc.* 8, No. 11, p. 1685-1688 (1953).
7. Schock and Subury, *Oil & Gas Journal*, 49, p. 73-74 (1950).
8. *NPN*, 35, No. 40, p. R-443-44, Oct. 6, 1943.
9. Happel, J., and Cauley, S. P., *Proc.* API, 21 M (III) p. 96 (1940).
10. *Pet. Proc.* 5, No. 3, p. 253-255 (1950).
11. Bartz, M. H., and Rawlins, C. E., *Pet Proc.*, 4, No. 8, p. 898-901 (1949).
12. Nelson, W. L., *Oil & Gas Journ.*, p. 107, Dec. 16, 1944.
13. Meerbott, W. K., Et. Al., *IEC*, 49, No. 4, p. 650-655 (1957).
14. Eberline, C. R., Et. Al., *IEC*, 49, No. 4, p. 661-663 (1957).
15. Stevenson, D. H. and Mills, G. A., *Pet. Ref.* 34, No. 8, p. 117-121 (1955).
16. Blade, O. C., *Oil & Gas Journ.*, Mar. 31, 1949.
17. Morrell, J. C., Et. Al., *IEC*, 28, p. 122 (1936).
18. Thompson, R. B., Et. Al., *IEC*, 41, p. 2715-21 (1949).
19. Meerbott, W. K., Et. Al., *IEC*, 46, No. 10, p. 2026-32 (1954).
20. Heinemann, H., Et. Al., *IEC*, 45, p. 800-802 (1953).
21. Steel, R. A., Et Al., *Pet. Engr.*, p. C-25, Feb. 1955.
22. Vesper, H. G., *Oil & Gas J.*, 54, p. 199-205, Nov. 21, 1955.
23. Sittig, M., and Warren, T. W., *Pet. Ref.*, 34, No. 9, p. 230-280 (1955).
23a. Anon., *Oil & Gas Journ.* 58, No. 12, p. 127 (1960).
24. Fairclough, H., *Pet. Ref.*, 35, No. 9, p. 333-335 (1956).
25. Le Nobel, J. W., and Choufcer, J. H., Fifth World Pet. Cong., Sect. III, Paper 18 (1959).
26. Based on U. S. Patent Nos. 2,695,866; 2,833,698; 2,834,718; 2,840,512; 2,840,513; 2,886,611; 2,890,165; 2,894,903; 2,900,323; and others pending.
27. *Pet. Proc.* 11, No. 11, p. 131 (1956).
28. Poll, H. F., *Pet. Ref.* 35, No. 7, p. 193-198 (1956).
29. *Pet. Proc.* 11, No. 11, p. 133 (1956).
30. Abbott, M. D., Archibald, R. C., and Dorn, R. W., *Pet. Ref.* 73, No. 5, p. 161-166 (1958).
31. McAfee, J., and Horne, W. A., *Pet. Proc.* 11, No. 4, p. 47-52 (1956).
31a. Vanderbilt, B. M., *IEC* 49, No. 4, p. 696-703 (1957).
32. Carlsmith, L. E., and Haig, R.R., *Pet. Ref.* 36, No. 9, p. 233-235 (1957).
33. Thornton, D. P., *Pet. Proc.* 12, No. 7, p. 119-121 (1957).
34. McAfee, Jerry, Et. Al., *Pet. Ref.*, 34, No. 5, p. 156-162 (1955).

DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas.**

Gulfining

Poor quality distillates ⟶ *high quality finished fuels*

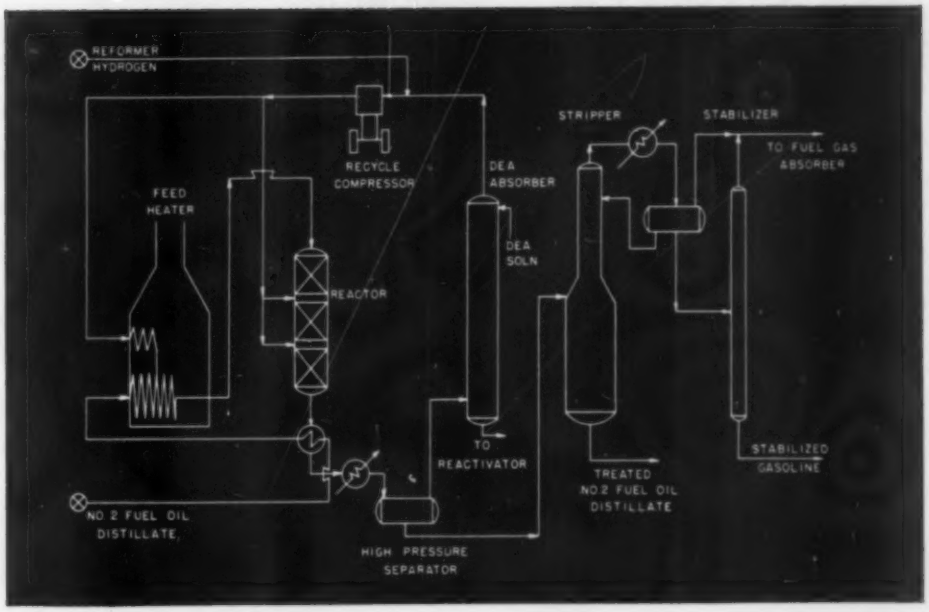
W. A. HORNE J. D. McKINNEY T. RICE
Gulf Research & Development Co.,
Pittsburgh, Pennsylvania

GULFINING is a middle distillate catalytic treating process which is carried out at elevated temperature and pressure in the presence of hydrogen. This process and an improved catalyst were developed at Gulf Research & Development Company. The Gulf Oil Corporation has four Gulfining units onstream with a combined capacity of 100,000 bbl per day, two at the Port Arthur, Texas, refinery and two at the Philadelphia, Pennsylvania, refinery. Charge stocks consist of West Texas and Kuwait straight-run furnace oil distillates, light catalytic gas oils, and visbreaker distillate. These streams are hydrogen treated with catalytic reformer off-gas which results in simultaneous hydrogenation and desulfurization, and an improvement in color stability and resistance to formation of sludge in storage.

A brief description of the process flow, the range of process variables, and typical inspection data are presented to indicate the desirable features of the process and the quality of products obtained from straight-run and cracked No. 2 fuel oil distillates derived predominantly from Kuwait crude processing.

Process Flow

A simplified flow diagram illustrating the principal processing equipment utilized for the Gulfining of No. 2 fuel oil distillates is presented in Fig. 1. The process utilizes a straightforward operation with the fresh feed being heat



exchanged with reactor effluent, preheated to 500 to 750 F in the presence of recycle hydrogen to which has been added fresh reformer hydrogen and passed downflow through a fixed-bed catalytic reactor.

The reactor is divided into three catalyst beds with intermediate redistributors where part of the recycle gas may be introduced to control the temperature gradient produced by the exothermic heat of reaction. The amount of quench gas is regulated to maintain the same temperature range in the middle and bottom catalyst beds as held in the top bed.

The reactor effluent is exchanged with fresh charge, cooled, and the liquid product recovered in high pressure separators. The separated recycle gas is passed through an amine tower to remove hydrogen sulfide, admixed with make-up reformer hydrogen and recompressed. The liquid product is flashed in a stripping tower where dissolved gases and a small amount of lower boiling hydrocarbons formed in the process are removed to yield the treated No. 2 fuel oil distillate as a bottoms product. The raw gasoline overhead is stabilized to remove the dissolved gases which are then combined with the fixed gases from the stripper and passed to an absorber to recover additional hydrogen sulfide.

The catalyst gradually loses activity during the course of processing because of a slow accumulation of a carbonaceous deposit. This deposit of carbon, hydrogen, and sulfur may require removal after a long operating period, normally greater than 100 bbl of oil charge per pound of catalyst. At such times, the activity of the catalyst may be restored by regeneration with air and steam or air and flue gas at a maximum temperature of 1100 F.

Process Variables

Basically, the objective of Gulfining is to produce high quality finished fuels from poor quality distillates. The reaction severity required depends upon the properties of the charge stock as well as the product quality desired. The least severe conditions are required for virgin stocks, the most severe for cracked distillates, and intermediate conditions for blends of the two types. The Gulfining reactions may occur in either vapor phase or mixed vapor and liquid phase. Hydrogen consumption is in the range of 30 to 100 cu ft per bbl for virgin distillates and over 300 cu ft per bbl may be used when charging highly-cracked, high sulfur stocks. As in other distillate hydrotreating processes, the hydrogen reacted can be predicted from olefin and sulfur inspection data for most charge stocks.

The general effect which a change in a variable has on the product is the same regardless of the origin of the charge stock although the magnitude of the effect does depend on the source. Cracked distillates which contain larger quantities of sulfur and unsaturated compounds are most susceptible to desulfurization and stability improvement. The principal variables which affect desulfurization are hydrogen partial pressure, space velocity, and temperature. All distillates are markedly improved in storage stability over the entire range of operating conditions utilized in Gulfining; therefore, incremental improvements obtained from increasing severity are small. The range of operating conditions which may be employed, depending upon the charge stock, is as follows:

Temperature: F	500-750
Pressure: psig	500-1000
Space velocity: vol./hr/vol	1.5-18
Hydrogen concentration: mole %	30-90
Recycle gas rate: scf/bbl	1000-4000

TABLE 1. Comparison of Gulf Low Density Catalysts and Conventional High Density CoMo Catalyst.

Catalyst		Product				Product		
		Conventional CoMo	Gulf	Improved Gulf		Conventional CoMo	Gulf	Improved Gulf
		—Commercial—		Pilot		—Commercial—		Pilot
Data Source	Charge			Plant	Charge			Plant
Inspections								
Gravity, °API	33.7	35.0	35.1	35.2	30.4	31.9	31.8	32.0
Color, ASTM Union	1.00	1.00	1.00	1.00	1.50	1.00	1.00	1.00
Sulfur, %	1.20	0.32	0.25	0.20	1.81	0.65	0.49	0.42
Neutralization Value Total Acid No.	0.07	Nil	Nil	Nil	0.21	Nil	Nil	Nil
Distillation, ASTM								
Over Point: F	280	414	395	390	242	374	340	340
End: F	650	650	646	648	661	659	653	655
10% at: F	452	466	460	458	441	434	427	425
50%	534	532	528	525	524	523	516	513
90%	610	604	600	600	604	605	598	598
Desulfurization: %	—	73.3	79.2	83.3	—	64.0	72.9	76.8

TABLE 2. Straight-Run and Gulfined Straight-Run Kuwait Furnace Oil Distillates.

	Full-Range Straight-Run		Heavy Straight-Run	
	Untreated	Gulfined	Untreated	Gulfined
Yield, Vol. % of Full Range Straight-Run Furnace Oil	100.0	99.9	53.0	53.1
Inspection Data				
Gravity: °API	38.8	40.6	34.4	37.2
Flash P-M: F				
ASTM D93-52	168	188	280	250
Pour Point: F				
ASTM D97-47	−10	0	+20	+20
Color, ASTM Union	1−	1−	1½−	1−
Doctor Test, ASTM D484-52	Sour	Sweet	Sour	Sweet
Sulfur, GRM 1123: %	1.08	0.06	1.64	0.17
Mercaptan Sulfur: %	0.018	<0.001	0.018	<0.001
Nitrogen: %	0.006	0.004	0.008	0.006
Pyrrole Compounds, as Indole, %				
GRM 1109	0.0004	0.0002	0.0005	0.0004
Carbon Residue, Conradson on 10% Bottoms: %	0			
ASTM D189-52	0.06	<0.01	0.01	0.01
Copper Strip Test, 212 F, 3 hr	1A	1A	—	—
Bromine No.				
ASTM D1159-52T	9.0	0.9	8.2	0.9
Aniline Point: F				
ASTM D611-1-53T	156	160	163	169
Neutralization Value (Acid No.)	0.04	0.01	0.11	0.01
Stability				
GRM 562, 210 F, 64 hr				
Color, ASTM Union, Initial	1−	1−	1½−	1−
Color, ASTM Union, End	1½−	1−	1½−	1−
Sediment: Mg./600 G.	6.4	2.5	1.2	1.3
Storage: 6 Months				
Color, ASTM Union	1−	1−	—	1−
Sediment: Mg/100Ml	0.2	0.3	—	0.9
Diesel Ignition Quality				
Ignition Delay Method: Cetane No.	54.0	57.3	56.4	58.9
Distillation, Gas Oil				
ASTM D158-54				
Over Point: F	372	400	532	499
End: F	642	632	650	638
10% at: F	433	435	551	530
50	510	498	575	564
90	602	596	621	614

The effect of temperature on the percent desulfurization is shown in Fig. 2 where the results obtained with a Gulf low density catalyst and a recently improved Gulf catalyst are compared with a conventional high density cobalt-molybdenum catalyst. These data illustrate the superior activity of the Gulf catalysts. A typical plot of the effect of space velocity on desulfurization is shown in Fig. 3. Long catalyst cycles, without regeneration, of one to two years duration may be obtained by choosing conditions which will give the desired quality improvements while maintaining minimum temperature.

A comparison which further illustrates the superiority of the Gulf catalysts is presented in Table 1. With the sulfur level in the charge ranging from 1.2 percent to about 1.8 percent, desulfurization over the low density catalysts is from 6 to 13 percent greater than over the conventional high density catalyst, even at the mild conditions utilized. In addition to its outstanding effectiveness in desulfurization, the use of the low density (less than 40 lb per cu ft) catalyst results in a substantial economic advantage because of lower investment and cost per barrel of throughput.

Product Properties

The primary objective in hydrogen treating is to improve product quality with particular emphasis on sulfur content and those properties which relate to stability during storage. Typical results obtained when Gulfining full-range straight-run and heavy straight-run Kuwait furnace oil distillates are shown in Table 2 and results obtained when charging a FCC light catalytic cycle oil and a visbreaker distillate from Kuwait crude are shown in Table 3. The inspections are representative of samples which had been in storage for at least six months. It should be noted that the yields of furnace oil distillate are in all cases essentially 100 percent by volume of charge.

All of the No. 2 fuel oil distillates are markedly improved in quality as judged by the usual inspections shown in Tables 2 and 3. It is of particular interest to note that the Kuwait full-range and heavy straight-run No. 2 distillates are improved equally well and a product of the same high quality results from Gulfining Kuwait visbreaker distillate. Althougth the FCC light cycle oil is greatly improved, the product is somewhat less desirable than the straight-run and visbreaker distillates because of its lower gravity and cetane index. However, its high heat content in Btu per gal makes it a very acceptable component of household heating oil.

TABLE 3. Gulfining of Catalytic and Visbreaker No. 2 Fuel Oil Distillates From Kuwait Crude.

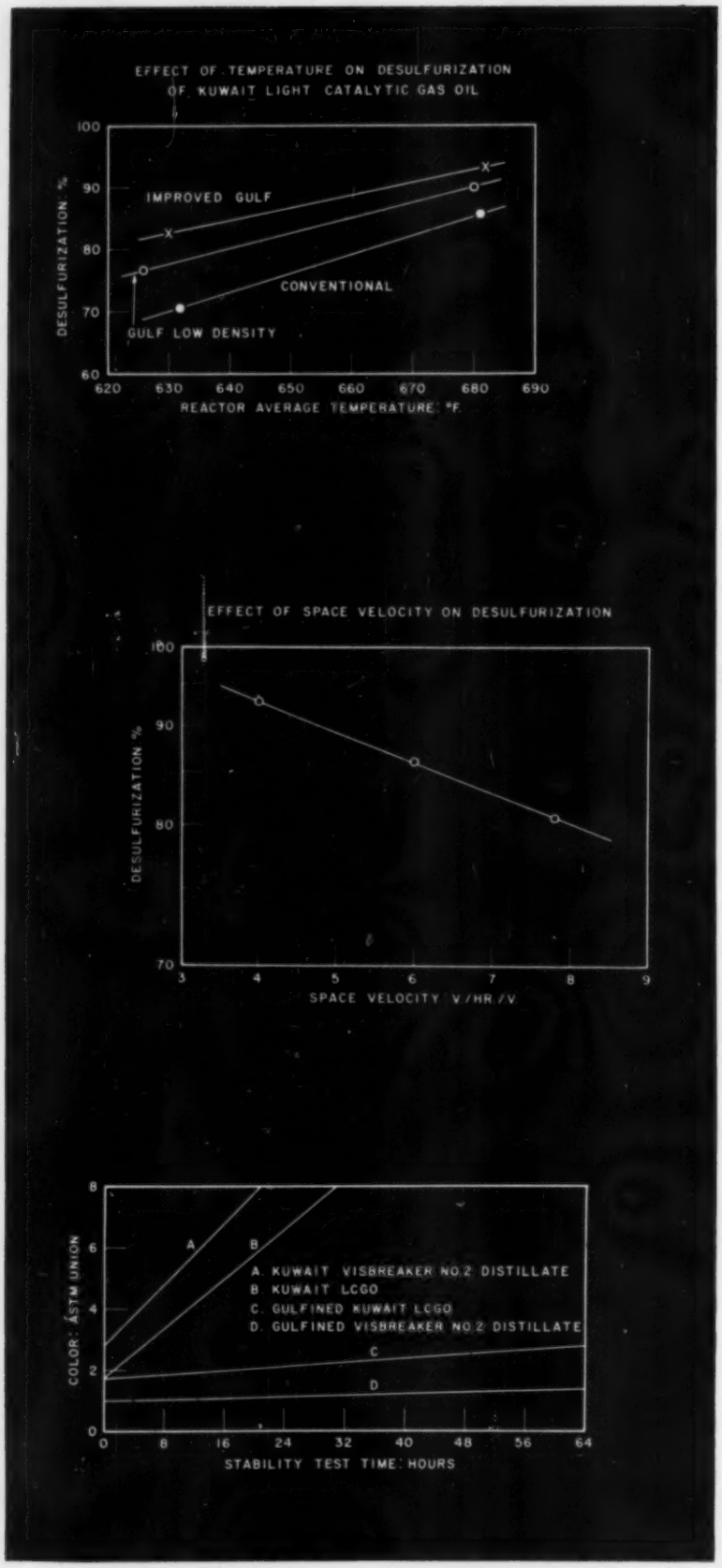
	FCC Catalytic Cycle Oil		Visbreaker Distillate	
	Untreated	Gulfined	Untreated	Gulfined
Yield, Vol. % of Charge	—	100.7	—	97.6
Inspection Data				
Gravity: °API	22.6	26.2	35.1	39.6
Flash P-M: F ASTM D93-52	208	196	<82	136
Pour Point: F ASTM D97-47	+5	+15	−15	−5
Color, ASTM Union	2—	2—	3—	1
Doctor Test, ASTM D484-52	Sour	Sweet	Sour	Sweet
Sulfur, GRM 1123: %	3.06	0.24	2.34	0.08
Mercaptan Sulfur: %	0.004	<0.001	0.022	<0.001
Nitrogen: %	0.033	0.026	0.033	0.016
Pyrrole Compounds, as Indole, % GRM 1109	0.0236	0.0156	0.0168	0.0065
Carbon Residue, Conradson on 10% Bottoms: % ASTM D189-52	0.23	0.05	0.10	0.04
Copper Strip Test, 212 F, 3 hr	1A	1A	4	1A
Bromine No. ASTM D1159-52T	30.9	13.5	54.5	3.4
Aniline Point: F ASTM D611-1-53T	84	89	125	146
Neutralization Value (Acid No.)	0.05	0.01	0.13	0.01
Stability				
GRM 562, 210 F, 64 hr				
Color, ASTM Union, Initial	2—	2—	3—	1
Color, ASTM Union, End	4— (Dil.)	3—	3½— (Dil.)	1½—
Sediment: Mg./100 G.	112.0	1.1	94.2	5.3
Storage: 6 Months				
Color, ASTM Union	7—	3—	6—	1½
Sediment: Mg./100Ml.	14.0	0.1	1.4	0.1
Cetane Index	27.3	31.8	47.6	55.3
Diesel Ignition Quality				
Ignition Delay Method: Cetane No.	—	—	45.6	52.0
Distillation, Gas Oil ASTM D158-54				
Over Point: F	425	386	202	312
End: F	645	638	635	640
10% at: F	469	447	408	429
50	535	520	508	496
90	609	605	594	590

TABLE 4. Properties of Naphtha Produced in Gulfining.

Charge	FCC Cycle Oil	Virgin Furnace Oil
Inspection Data		
Gravity: °API	32.2	52.9
Sulfur, %	0.02	0.01
Color, Saybolt	+25	+30
Bromine No.	1.5	1.1
Hydrocarbon Type, FIA: % by Vol.		
Aromatics	89.6	—
Olefins	2.1	—
Saturates	8.3	—
Knock Ratings Motor Method: Octane No.		
Clear	87.9	48.0
+3 Cc. TEL	92.2	72.1
Research Method: Octane No.		
Clear	104.0	40.0
+3 Cc. TEL	107.3	70.1
Distillation, Naphtha ASTM D 86		
Over Point: F	320	221
End: F	391	366
10% at: F	331	258
50	350	302
90	379	336

Gravity increase for straight-run stocks is 1°API to 3°API compared to an increase of 3°API to 5°API for catalytically or thermally cracked stocks at commercial operating conditions. The extent of desulfurization is normally in the range of 70 to 95 percent with essentially complete removal of mercaptans and Gulfined distillates are Doctor sweet even without a final caustic wash. Nitrogen compounds are removed with more difficulty than sulfur compounds. Total nitrogen is decreased only about 20 to 50 percent and pyrrole compounds to a slightly greater extent, up to 60 percent. The compounds removed, however, probably correspond to the more reactive types. The neutralization value is reduced to 0.01 in all cases indicating almost complete removal of acidic compounds.

Color of the product from freshly prepared charge stock is usually unchanged or slightly improved. A marked improvement results if the



charge consists of an unstable distillate which has darkened in storage. Color instability and sludging in storage are believed to be caused by the same type reactions. A darkening in storage is apparently the result of the formation of soluble gum whereas sludge precipitation is caused by insoluble gum. These gums which form during storage of an unstable fuel are thought to be end products of oxidation and polymerization reactions. Although the exact reactions are unknown, there are definite indications that their formation is related to the presence of nitrogen, sulfur, and oxygenated compounds. It is also well known that unstable diolefinic hydrocarbons form in cracking reactions and are easily converted to gums.

The data in Fig. 4, 5, and 6 illustrate the great improvement in color stability and resistance to insoluble sludge and carbon residue formation obtained by Gulfining cracked Kuwait furnace oils. The accelerated test, Gulf Research Method 562, shows there is little or no increases in color after 64 hours at 210 F and the quantity of sediment formed is reduced in all cases to well below the acceptable limit. Data in Tables 2 and 3 show that there is less change in product properties with six months storage than is obtained in the accelerated test and illustrate the excellent stability obtainable with Gulfining. Kuwait virgin furnace oil distillates are quite stable in storage so stability improvements are less noticeable for these stocks.

A small amount of synthetic naphtha is produced primarily from desulfurization reactions. The furnace oil distillation does not change to any appreciable extent when the product is stripped. The properties of the naphtha stripped from the No. 2 distillate are shown in Table 4. Naphtha from Gulfining the cycle stock is very aromatic and has high octane numbers. Naphtha from Gulfining the virgin furnace oil is very similar to straight-run naphtha.

Gulfining is also used for upgrading raw kerosine to meet the low sulfur content and high burning quality requirements of commercial kerosine-turbine fuel. As shown in Table 5 Gulfined Kuwait kerosine has a low sulfur content of 0.004 percent, Saybolt color is improved to $>+30$, and the color stability and burning qualities are good. This operation produces a kerosine satisfactory in all respects for normal kerosine requirements and makes a good blend stock for turbine fuels.

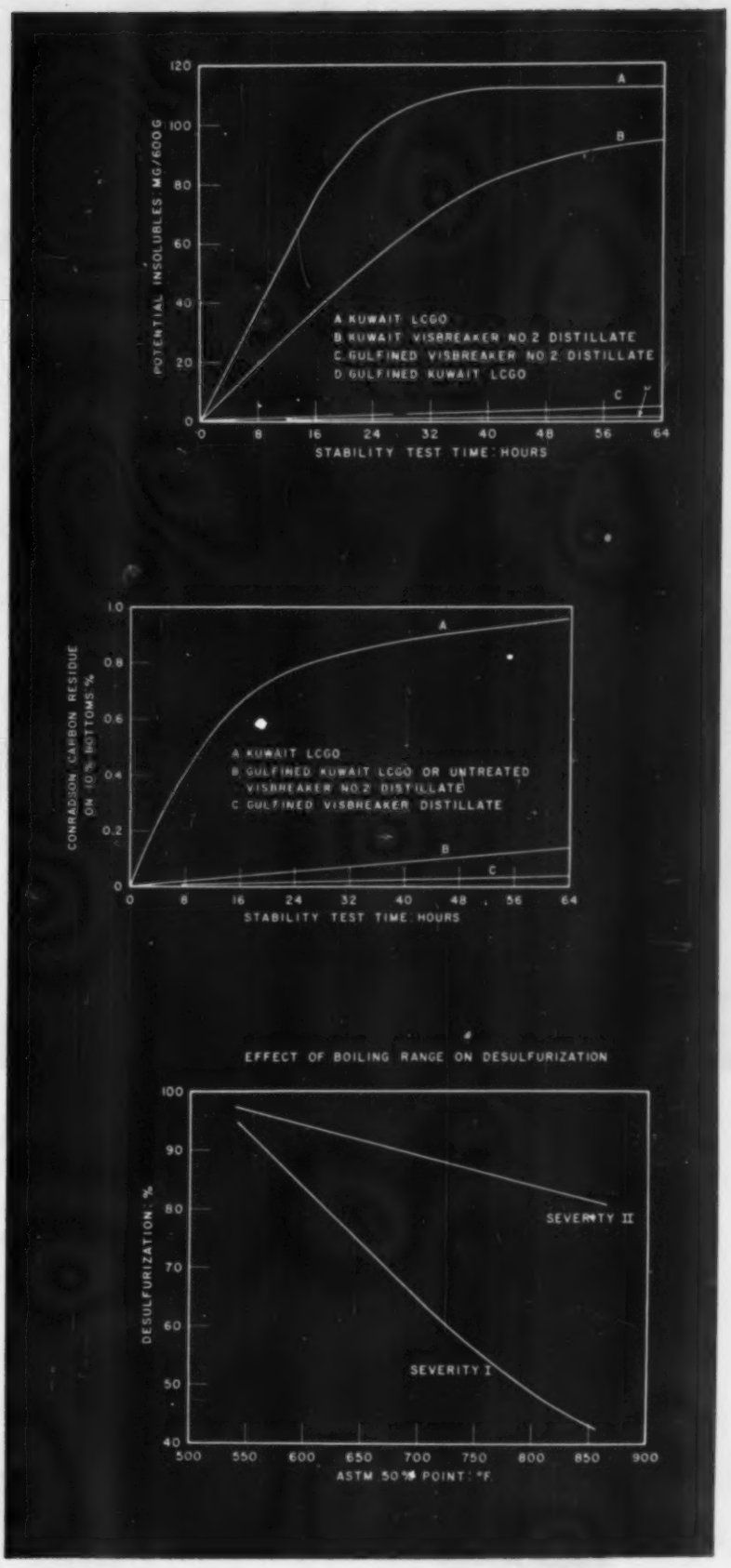
Although Gulfining has been used principally to upgrade kerosine and furnace oil, it is applicable to a wide range of distillates. However, the boiling range of the charge stock has con-

siderable effect on the degree of desulfurization. For a mild operation (Severity I) Fig. 7 shows that as the ASTM 50 percent point increases from 550 F to 850 F, the percent desulfurization decreases from 93 to 43 percent. For a more severe operation (Severity II) the effect of boiling range on percent desulfurization is substantially less and thus a high degree of desulfurization can be obtained on the heavier stocks.

From the foregoing brief summary, it can rightly be concluded that a wide variety of operating conditions can be utilized to Gulfine No. 2 fuel oil distillates to obtain low sulfur, stable products. It is obvious, however, that certain groupings of process variables lead to a more flexible operation. Extreme conditions lead to catalyst fouling, and product quality cannot be maintained for the 6 to 24 months desirable between catalyst regenerations. The actual choice of conditions for Gulfining, however, will depend upon the results of process and economic studies applied to a particular refinery situation.

TABLE 5. Properties of Raw and Gulfined Kuwait Kerosines.

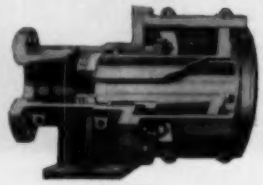
Inspections	Charge	Product
Gravity: °API	44.1	45.1
Sp. Gr., 60°/60 F	0.8058	0.8012
Viscosity, S Thermo V, 60 F	377	372
Flash, TCC: F		
ASTM D56-52	150	152
Color, Saybolt	+15	>+30
Saybolt after 16 hr	—	+30
Doctor Test: FS-5203	Fail	Pass
Odor	Fail	Normal
Sulfur: %	0.463	0.004
Mercaptan Sulfur: %	0.009	Nil
Bromine No., ASTM D 1159	3.7	0.5
Hydrocarbon Type: (FIA) % by Vol. ASTM D 1319		
Aromatics	17.6	17.2
Olefins	3.1	2.3
Saturates	79.3	80.5
Copper Strip Corrosion 212 F, 3 hr ASTM D 130-55	1B	1A
Burning Test, ASTM D 187, 24 hr	Fair	Good
Average Burning Rate: Ml./hr.	39.0	42 2
Cetane Index, CFR	50.6	52 8
Smoke Point, Mm.	24.3	25.4
Distillation, ASTM D86		
Over Point: F	356	358
End Point: F	504	500
10% at: F	378	378
20	388	388
30	396	396
40	408	402
50	420	420
60	436	434
70	450	448
80	468	464
90	486	480
95	494	492
Recovery: %	98.5	98.5
Residue	0.8	1.0
Loss	0.7	0.5


POTENTIAL INSOLUBLES: MG/100 G
STABILITY TEST TIME: HOURS
A KUWAIT LCGO
B KUWAIT VISBREAKER NO 2 DISTILLATE
C GULFINED VISBREAKER NO 2 DISTILLATE
D GULFINED KUWAIT LCGO
CONRADSON CARBON RESIDUE ON 10% BOTTOMS %
STABILITY TEST TIME: HOURS
A KUWAIT LCGO
B GULFINED KUWAIT LCGO OR UNTREATED VISBREAKER NO 2 DISTILLATE
C GULFINED VISBREAKER DISTILLATE
EFFECT OF BOILING RANGE ON DESULFURIZATION
DESULFURIZATION: %
ASTM 50% POINT: °F
SEVERITY II
SEVERITY I

ONLY ADSCO HAS ALL 3 TYPES OF EXPANSION JOINTS

CORRUFLEX PACKLESS

RAM-PAK



SLIP TYPE

. . . real peace of mind, the result of doing business with completely reliable Adsco. For more than 80 years, Adsco has carefully handled customers' expansion problems in their piping systems, from engineering through manufacture. Consult Adsco for your peace of mind.

Write for comprehensive catalogs

ADSCO ENGINEERED PRODUCTS

Sold, Engineered and Manufactured by

YUBA HEAT TRANSFER DIVISION

HONESDALE, PA.

World's Oldest and Largest Manufacturer of Packed and Packless Expansion Joints

YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

YUBA — A growth corporation serving growth industries

chemical
petroleum
steam — electric
hydro — electric
aeronautics
construction
heating
air-conditioning
consumer durable

Hydrogenation of

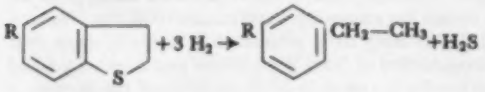
catalytic cracking feedstocks

C. C. WILLIAMS M. D. ABBOTT
Shell Development Company, Emeryville, California

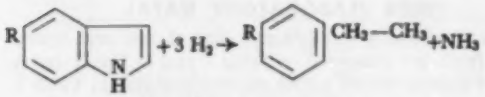
CATALYTIC CRACKING FEEDSTOCK quality has been shown to be adversely affected by the presence of polyaromatic compounds,[6] nitrogen bases,[12] and trace metal contaminants such as nickel and vanadium.[5] These undesirable constituents can be removed or altered by hydrogenation. Products from the catalytic cracking of hydrotreated vacuum gas oils and deasphalter overheads have also been found to be of higher quality than those from untreated feeds.[1,2,4,7,10] For these reasons, there has been a continuing interest in and some commercial acceptance of catalytic cracker feed hydrogenation.

Shown below are some of the typical reactions occurring with compounds in the gas oil and heavier range:

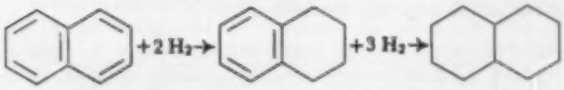
Desulfurization:



Nitrogen Removal:



Polyaromatics Hydrogenation:



Much has already been written on the removal of sulfur and nitrogen by hydrotreating. The data presented in Fig. 1 indicate, for example, the degrees of desulfurization and denitrification attainable in laboratory studies with a low-sulfur West Texas flashed distillate. As shown, the selectivity for sulfur removal improves at lower pressures, while that for nitrogen removal appears to be pressure invariant. Removal of both of these heteroatoms is favored by increases in reaction temperature.

Polyaromatic hydrocarbons are, as noted above, undesirable in catalytic cracker feeds since their nuclei are difficult to crack, form a disproportionate amount of coke, and contribute little to the important product yields. On the other hand, when hydrogenated to monoaromatic or naphthenic compounds, their catalytic cracking properties are very good. In a typical flashed distillate from West Texas crude, polyaromatics are present in concentrations of 15 to 25 percent mole; in a recycle gas oil, the concentrations fall in the 30 to 40 percent mole range.

Polyaromatic hydrocarbons can be hydrogenated under a variety of pressures, e.g., from 750 to 3000 psig or higher. Two observations have been made which influence the choice of hydrogenation pressure within such a range:

(a) in general, the hydrogenation rate is greatest at the highest pressure, and

M. D. Abbott, *engineer in Shell Development's Oil Process Engineering Department, has for many years been active in development, process design, and economic evaluation of oil refining processes. He attended Massachusetts Institute of Technology for undergraduate and graduate studies in chemical engineering from 1933 to 1938. Before joining Shell in 1953, he worked for Humble Oil & Refining Company and C. F. Braun & Co. During World War II he participated in work of the Manhattan Project at Chicago.*

C. C. Williams, *a supervisor in Shell Development's Oil Process Engineering Department, Emeryville, California, received his bachelor of engineering degree from Yale University and hold SM and ScD degrees from Massachusetts Institute of Technology. Since joining Shell in 1953, he has been engaged in design and economic evaluation of oil processes, with particular emphasis on hydrogenation, catalytic cracking, and urea extraction. He is a member of the ACS, AIChE, Tau Beta Pi, Sigma Xi, and Alpha Chi Sigma.*

(b) there is an equilibrium between polyaromatics and their hydrogenated products, which is more favorable at high pressures.

Mono- and polyaromatics contents are shown in Fig. 2 as functions of pressure and depth of hydrogenation. At low hydrogen consumptions, polyaromatics are hydrogenated to monoaromatics more rapidly than the latter are saturated. As saturation is increased, the monoaromatics pass through a maximum concentration, with polyaromatics continuously decreasing. After reaching a peak, monoaromatics concentration also declines. The shapes of these curves depend upon the relative rates of hydrogenation of the different classes of aromatics and on the equilibrium among them. It will be observed that the reduction of polyaromatics improves with increasing pressure, although the selectivity gains above 1500 psig appear to be relatively slight.

Trace metals, normally found in the overheads from feed preparation processes, are known to have a detrimental effect on catalytic cracking yields. Recently published commercial and laboratory data[5,9] indicate, for example, that coke and hydrogen yields increase and gasoline decreases with increasing accumulation of nickel on synthetic cracking catalyst. Passage over a hydrogenation catalyst is an effective means for removing these metals from the cracking unit feed. Laboratory data, presented in Table 1, show that mild hydrogenation of both West Texas and Kuwait flashed distillates results in rejection of 80 to 95% of the metals.

CATALYTIC CRACKING OF HYDROGENATED FEEDS (LABORATORY DATA)

Yields from the laboratory cracking of raw and hydrogenated feeds are presented in Table 2 and in Fig. 3 and 4. Pertinent hydrogenation yields are also included in Table 2. The small amount of gasoline formed during hydrogenation has been found to be an excellent catalytic reformer feed, owing to its high naphthene content.

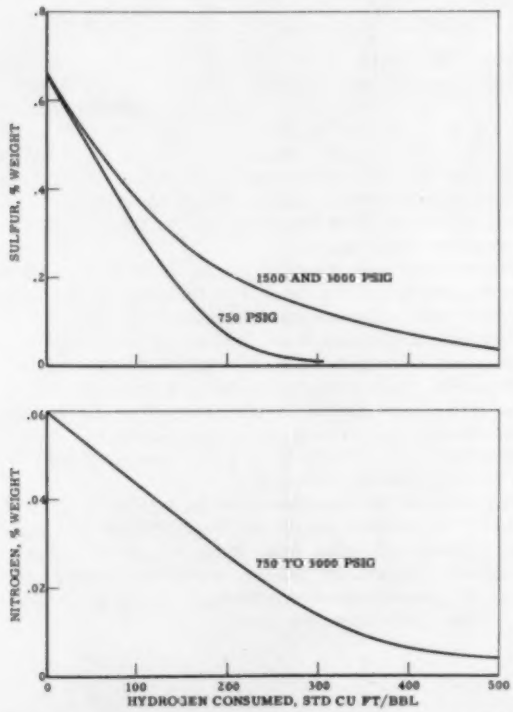


FIG. 1. Sulfur and nitrogen content of hydrogenated low-sulfur West Texas flashed distillate.

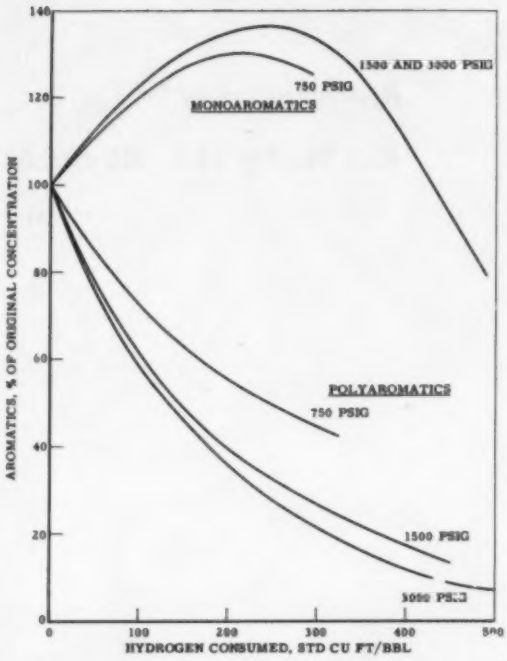


FIG. 2. Aromatics content of hydrogenated low-sulfur West Texas flashed distillate.

Catalytic cracking data on West Texas and Kuwait flashed distillates show coke reductions of up to 65 percent (basis coke) and gasoline yield increases of up to 20 percent (basis gasoline), at constant conversion. At constant catalytic coke, gasoline yield is improved as much as 40 percent. These benefits are accompanied by increased yields of propylene, butylene and reduced dry gas (ethane and lighter) makes.

All the results reported here were obtained using the same catalyst for both the untreated feed and hydrogenated gas oils. The catalytic cracking yields do not therefore reflect the additional yield advantages which result when the hydrogenated stock is cracked over a catalyst less contaminated than that used for the untreated feed. These additional yield benefits should, however, be realized in commercial operation, because of the aforementioned metals reduction obtained through hydrogenation.

In addition to the yield advantages, the quality of gasoline and gas oil from a hydrogenated feed is superior to that from an untreated stock as illustrated in Table 3. Catalytic gasoline from the hydrogenated flashed distillate tests higher in octane number, both motor and research, and lower in sulfur content. For the light gas oil, sulfur is decreased appreciably, diesel index is higher and color stability is

TABLE 1. Heavy Metals Content of Hydrogenated Flashed Distillates.

	West Texas Flashed Distillate			Kuwait Flashed Distillate		
	Concentration in Parts Per Million			Concentration in Parts Per Million		
	Untreated	210 SCF H_2 per BBL	Percent Reduction	Untreated	320 SCF H_2 per BBL	Percent Reduction
Iron	1.3	.028	95+	.91	.084	90
Copper	.013	.0049	60	.049	.0088	80
Nickel	.13	.012	90	.17	.026	85
Chromium	.0046	.0028	50	.014	.0035	75
Vanadium	.19	.013	95	.88	.034	95
Sodium	.26	.015	95	.86	.46	45
Magnesium	.029	.0064	80	.096	.016	85
Calcium	.055	.012	70			

improved. These advantages make possible both a better furnace oil and better diesel fuel from a hydrotreated feed to catalytic cracking. The increase in gravity and decrease in sulfur, nitrogen and viscosity of the heavy gas oil indicate an improved thermal cracking feed.

Heavy catalytically cracked gas oil, on which data are given in Table 2, is typical of either recycle stocks or of feeds to the second stage of a two-stage catalytic cracker.[6] The cracking yield improvements as a result of hydrogenation are of the same order as those attainable via solvent extraction.[11] The high liquid yields in hydrogenation are, however, an advantage in cases where an aromatic gas oil extract would otherwise have to be disposed of as residual fuel.

COMMERCIAL OPERATIONS

Results are now available from several commercial units in which vacuum gas oils and deasphalted oils are hydrogenated prior to catalytic cracking.[1,3,7] The reported reductions in undesirable components fall in the following ranges:

Sulfur	70 - 80%
Nitrogen	20 - 30%
Conradson Carbon	40 - 65%
Metals (Nickel plus Vanadium)	60 - 92%

Typical and more detailed operating data, from the processing of Kuwait flashed distillate at the Shell Oil Company of Canada Montreal refinery, are shown in Table 4.

Hydrogenated product (stripper bottoms) from this unit is usually cracked in admixture with untreated feeds from other crudes. Included in Table 4 are, however, results from test runs which indicate the yield changes that would result if the Kuwait stocks were cracked alone. The increase in gasoline make, resulting from hydrogenation, is about 7 percent (basis gasoline) while the decrease in the combined yield of coke and ethane and lighter is about 25 percent (basis coke plus ethane and lighter). The improved feed quality, indicated in Table 4, could be exploited in a catalytic cracking unit which is limited only by coke-burning capacity by (1) either increasing conversion about 10 percent (basis feed) at constant feed rate or (2) by increasing feed rate about 35 percent at constant conversion. Deeper feed preparation could also be employed, since metals and coke precursors are removed by hydrogenation.

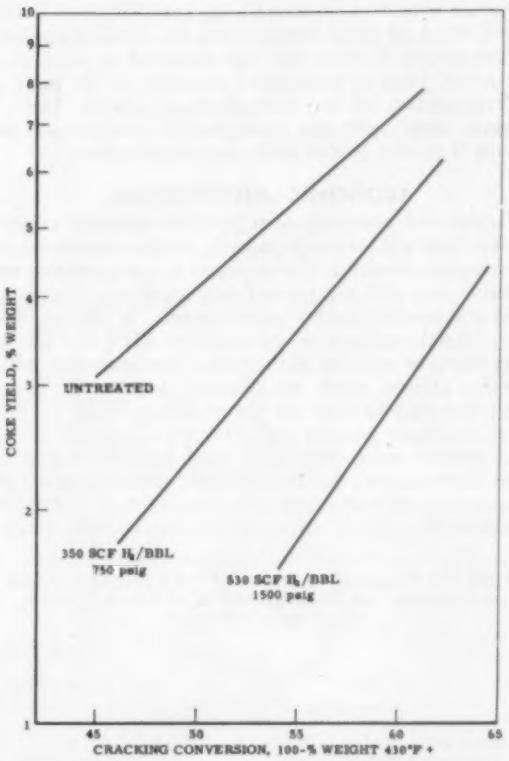


FIG. 3. Coke yield from catalytic cracking of hydrogenated West Texas flashed distillate.

Because the commercial cracking tests reported above for the untreated and the hydrogenated feeds were made within a few days of each other, the metal contaminants contents of the cracking catalysts were identical for the two tests. The cracking yields do not, therefore, reflect the additional advantages that would have resulted if equilibrium catalysts had been used in each test. While laboratory

TABLE 2. Experimental Hydrogenation of Catalytic Cracking Feedstocks.

Hydrogenation	West Texas Flashed Distillate			Kuwait Flashed Distillate			Catalytically Cracked Heavy Gas Oil	
Pressure, psig		750	1500		750	1500		750
Hydrogen consumed, scf/bbl	none	350	530	none	375	455	none	500
Yields, % by weight of hydrogenation feed								
Hydrocarbon gas (butane and lighter)		0.3	0.6		0.3	0.3		0.2
Heterogas (H_2S, NH_3, H_2O)		1.7	1.8		2.6	2.7		1.7
Gasoline (C_5 to 450 F)		2.9	4.0	1.3	2.7	3.3	100.0	99.0
Gas oil	100.0	95.6	94.5	98.7	95.1	94.5		
Yield of total liquid product, (gasoline plus gas oil), % volume	100.0	100.6	101.5	100.0	101.0	101.7	100.0	101.7
Properties of Catalytic Cracking Feed[a]								
Gravity, °API	25.5	28.4	29.9	23.4	28.4	29.5	21.5	25.7
Sulfur, % weight	1.68	0.12	0.05	2.91	0.44	0.32	1.52	0.09
Nitrogen, % weight	.13	.05	.02	.08	.05	.03	.07	.05
Monoaromatics, %m	23	28	27	24	32	34	12	20
Polyaromatics, %m	21	10	6	23	13	8	38	24
Catalytic Cracking Yields, % by weight of catalytic cracking feed								
At constant conversion								
Conversion (100-%w 430 F+)	56	56	56	55	55	55	50	50
Coke yield	5.8	3.9	2.0	5.6	3.7	2.5	12.6	7.1
Gasoline yield (C_5 to 430 F)	33.1	35.2	37.5	32.6	35.7	37.1	23.1	28.1
At constant coke								
Conversion (100-%w 430 F+)	49.5	56.3	63.4	49.7	56.2	60.0	42.5	56.5
Coke yield	4.0	4.0	4.0	4.0	4.0	4.0	10.0	10.0
Gasoline yield (C_5 to 430 F)	31.8	35.2	39.0	31.8	36.0	38.3	21.0	29.3

[a]Hydrogasoline (C_5 to 450F) remained in catalytic cracking feed in the Kuwait and the cracked gas oil studies. Hydrogasoline was distilled out of catalytic cracking feed in the West Texas flashed distillate studies.

and plant data have indicated quite conclusively the detrimental effect of metal contaminants on cracking catalysts, no comparable ill effect has been observed in about three and a half years of commercial operation as the result of their deposition on the hydrogenation catalyst. There is however, little doubt that hydrogenation catalysts will lose activity if heavily loaded with contaminant metals.[7]

ECONOMIC JUSTIFICATION

Capital and operating costs for hydrogenating catalytic cracker feed will vary with capacity, design conditions, and construction standards. The optimum design conditions will, in turn, vary with the type of feed stock and the desired yield and product quality improvements. In general, however, capital costs are in the range of $100 to $200 per daily barrel of capacity and the direct operating cost, which includes utilities, labor, maintenance, and catalyst is normally less than 10 cents per bbl of feed.

Of the many possible applications for catalytic cracker feed hydrogenation, two seem most likely to justify the costs mentioned above. One situation might be where the introduction of a new high-sulfur crude creates a need for desulfurizing one or more of the catalytically cracked products. In this case, the desired sulfur reduction might be obtained by hydrogenating either the products from or the feed to the catalytic cracker. The economics in this case depend, in part, on the size of the required feed hydrogenation unit relative to that of the product hydrodesulfurizer replaced. In some applications studied, the capital and operating costs of the feed hydrogenation unit are only slightly greater than the comparable figures for the product treater. In this situation, the economics for catalytic cracking feed hydrogenation are quite favorable.

TABLE 3. Properties of Products From Catalytic Cracking of Untreated and Hydrogenated West Texas Distillate. (Constant Conversion)

	Untreated Feed[a]	Hydrogenated feed 460 scf H_2 per bbl
Gasoline (70 F to 450 F)		
Research octane number (ASTM D-908)		
Without TEL addition	94.0	95.3
With addition of 3 ml TEL/gal	98.0	99.6
Motor octane number (ASTM D-357)		
Without TEL addition	84.1	86.0
Sulfur, %w	.18	.01
Light Gas Oil (450 F to 675 F)		
Gravity, °API	21.4	25.6
Sulfur, %w	1.5	.12
Aniline Point, F	104	117
Diesel index	22	30
Color, ASTM		
Without ageing	1½	1¼
After ageing at 212 F		
For 24 hours	3¼	1¾
For 48 hours	3¾	2¼
Heavy Gas Oil (675 F+)		
Gravity, °API	15.1	22.2
Sulfur, %w	1.4	0.34
Nitrogen, %w	.08	.03
Viscosity, SSU at 210 F	40	38

[a]Contains 0.6% naphtha which may lower octane numbers of catalytic gasoline by approximately 0.3 units. Hydrogenated feed contains no naphtha.

TABLE 4. Performance of Commercial Catalytic Cracking Feed Hydrogenation Unit.

	Feed	Stripper Liquid tops	Stripper Bottoms
Hydrogenation			
Yield, % volume	100	0.7	99.9
Gravity, °API	23.2	45.4	27.3
Sulfur, % weight	2.78	.38	.58
Conradson carbon, % weight	.45	—	.16
Monoaromatics, %m	22	—	31
Polyaromatics, %m	22	—	12
Nitrogen (basic), ppm	470	—	360
Color, NPA	7	—	3
ASTM distillation, F			
Initial boiling point	582	—	460
50 Percent point	680	—	680
Catalytic Cracking			
Conversion, 100—%w 450 F+	57.7	—	58.4
Yields, % weight of catalytic cracking feed			
Gasoline (C_5 to 450 F)	35.1	—	37.6
Coke	6.1	—	4.4
Ethane and lighter	3.8	—	3.0

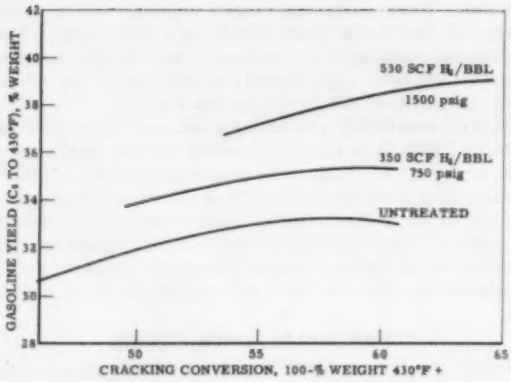


FIG. 4. Gasoline yield from catalytic cracking of hydrogenated West Texas flashed distillate.

Another attractive application would involve hydrogenating catalytic cracker recycle stocks. Theoretical considerations and laboratory tests indicate that these aromatic materials can be hydrotreated under mild conditions to give a considerable improvement in cracking quality. Economic studies, described elsewhere,[1] show the hydrogenation of such stocks to be highly profitable.

It should also be noted that catalytic cracker feed hydrogenation is a proved method of increasing a refinery's gasoline production at the expense of distillates. As such, it is of interest in view of current intermediates surpluses.

ACKNOWLEDGMENT

The authors acknowledge the contributions of their colleagues at Emeryville and throughout Shell Oil Company and particularly of Messrs. **R. C. Archibald, C. P. Brewer** and **R. W. Dorn.**

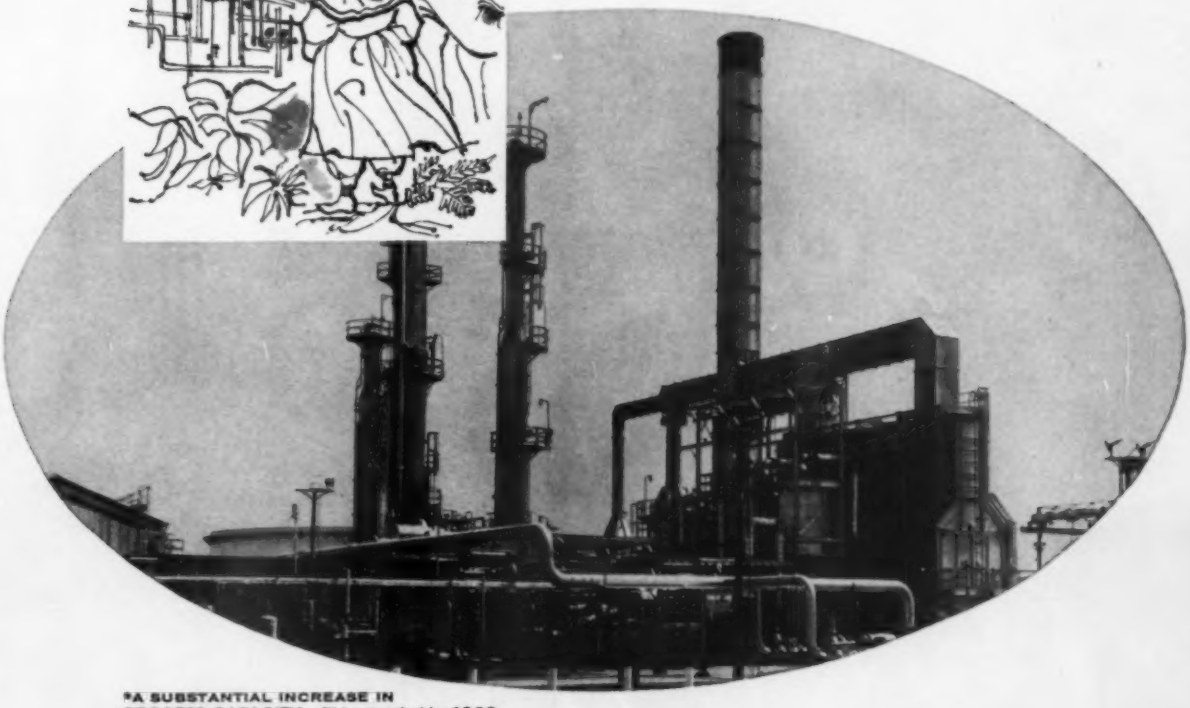
References

1. Abbott, M. D., Archibald, R. C., and Dorn, R. W., "Improvement of Catalytic Cracking Feedstocks by Hydrogenation," *Oil & Gas Jour*, 56, 144 (May 19, 1958).
2. Bradley, W. E., Hendricks, G. W., Huffman, H. C. and Kelley, A. E., "Hydrogenation — Here Today and Here Tomorrow," *Oil & Gas Jour*, 57, 194 (June 8, 1959).
3. Connally, H. T., "Catalytic Desulfurization of Cat Cracker Charge Stock," *Oil & Gas Jour*, 57, 88 (September 14, 1959).
4. Eberline, C. R., Wilson, R. T. and Larson, L. G., "Hydrotreating Cracking Stocks," *Ind Eng Chem*, 49, 661 (1957).
5. Gossett, E. C., "The Effect of Catalyst Metal Poisoning on Fluid Cracking Yields," Paper presented at 52nd Annual AIChE Meeting, San Francisco, (December 9, 1959).
6. Greensfelder, B. S., Voge, H. H. and Good, G. M., "Catalytic Cracking of Pure Hydrocarbons," *Ind Eng Chem*, 37, 1168 (1945).
7. Gwin, G. T., "Optimal Utilization of Byproduct Hydrogen in an Integrated Oil Refinery," Paper presented at 24th Midyear Meeting of the API Division of Refining, New York (May 27, 1959).
8. Heldman, J. D., Kunreuther, F., Marshall, J. A. and Rehbein, C. A., "Cat Cracking Now in Two Stages," *Pet Refiner*, 35, No. 5, 166 (1956).
9. Herthel, E. C., Reynolds, E. H. and Roe, J. H., "How Richfield Reduced Catalytic Cracker Feed Contamination," *Oil & Gas Jour*, 58, 86 (February 1, 1960).
10. Lewis, E. H., "Hydrofining Catalytic Cracking Feedstocks," *Oil & Gas Jour*, 54, 95 (July 18, 1955).
11. Shelley, C. W. and Rackley, C. W., "Better Yields from Cat Cracking," *Pet Processing*, 7, 1772 (1952).
12. Viland, C. K., "Better Yields after Nitrogen Removal," *Pet Refiner*, 37, No. 3, 197 (1958).

★ ★ ★

DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas.**

*'62 could be the year for you



*A SUBSTANTIAL INCREASE IN PROCESS CAPACITY will be needed by 1962, according to reliable estimates . . . NOW is the time to start your planning!

PROCON *Incorporated*

1111 MT. PROSPECT ROAD,
DES PLAINES, ILLINOIS, U. S. A.

PROCON INTERNATIONAL S. A.
PROCON (CANADA) LIMITED, TORONTO 10, ONTARIO, CANADA
PROCON (GREAT BRITAIN) LIMITED, LONDON, W. C. 2, ENGLAND
PROCON PTY. LIMITED, SYDNEY, AUSTRALIA
PROCOFRANCE S.A.R.L., PARIS, FRANCE
PROCON LIMITADA, SAO PAULO, BRAZIL
VICAPROCON, S. A., CARACAS, VENEZUELA

PROCON

WORLD-WIDE CONSTRUCTION
FOR THE PETROLEUM, PETROCHEMICAL,
AND CHEMICAL INDUSTRIES

STAMP OF CHARACTER—YOURS!

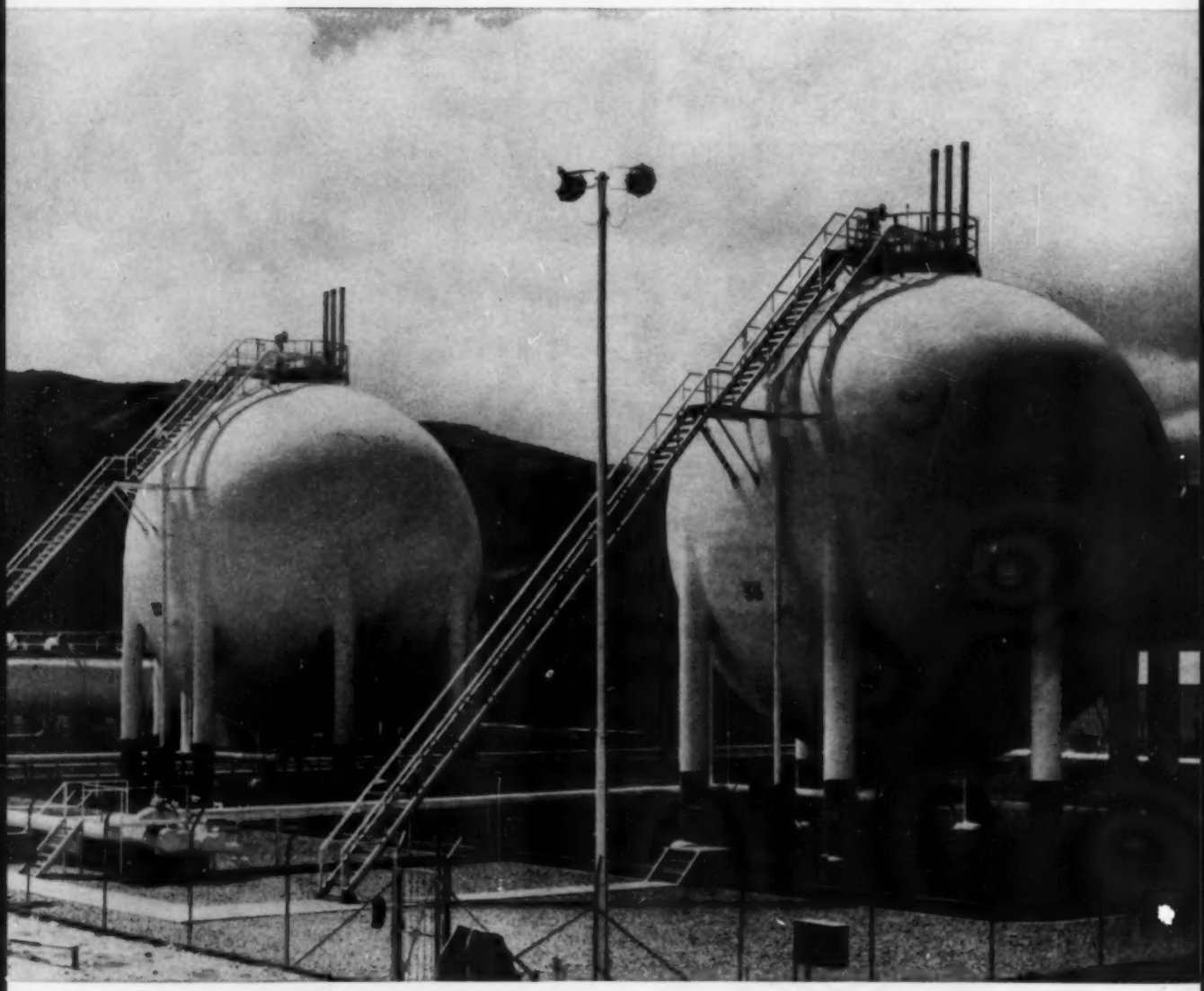
As personal as your signature! As individual as you! That's the kind of plant you get when you entrust the construction to Procon.

Process designs, flow charts, piping designs, plot plans, all take shape under the hands of skilled designers and construction-wise engineers. These men make the job as distinctively yours as your portrait!

At home or abroad, for petroleum, petrochemical or chemical processing, creative construction by Procon is your assurance of a plant built as you want it, to operate exactly as specified.

Before you plan for your next expansion or plant improvement program, consult Procon.

Now you can cut pressure vessel weight



The use of 299 tons of USS "T-1" Steel in these two Hortonspheres saved 216 tons of carbon steel and 42% in shipping costs. Designed and erected by Chicago Bridge & Iron Company for storing propane gas in Venezuela. These tanks were designed to the old code limits, but under the new code limits they could have been made up to 9.5% lighter.

Revisions in case 1204-4 of the ASME Code for boilers and pressure vessels increase maximum allowable stress value to 28,750 psi for "T-1" Steel. This permits further reductions in weight up to 9.5%.

even more with USS "T-1" Steel

The new figure of 28,750 psi represents an increase of 9.5% over the previous maximum allowable stress value of 26,250 psi which applied to USS "T-1" Constructional Alloy Steel used in pressure vessels. This means that USS "T-1" Steel can be used to reduce weight even more than it did before in stationary vessels or truck tanks.

The steel frequently used in welded, unfired pressure vessels is ASTM A-285-Grade C. This steel can be used with a maximum allowable design stress of 13,750 psi. From this, you can see that the allowable stress for "T-1" Steel is 2.1 times greater. To put it another way, plates of "T-1" Steel in a pressure vessel need be only half the thickness of A-285-C plates to withstand the same stress.

15% overall savings possible with "T-1" Steel

USS "T-1" Steel permits a 50% reduction in the amount of steel used in the vessel; this results in large savings in the cost of structural supports and foundations, welding, freight, handling costs and the elimination of stress relieving costs.

In a recent design, pressure vessels designed of both A-285-C steel and "T-1" revealed the following cost analysis:

	Use of "T-1"
Weight of steel	saved 50%
Cost of steel	only 20% more
Fabrication cost	saved 40%
Freight	saved 50%
Amount welding wire	saved 60%
Total savings	**15% cheaper overall**

These savings, plus USS "T-1" Steel's unique combination of toughness at low temperatures, high strength at elevated temperatures, and weldability, offer the pressure vessel designer the *only* material of this high strength level possessing *all* the qualities so important in the pressure vessel field.

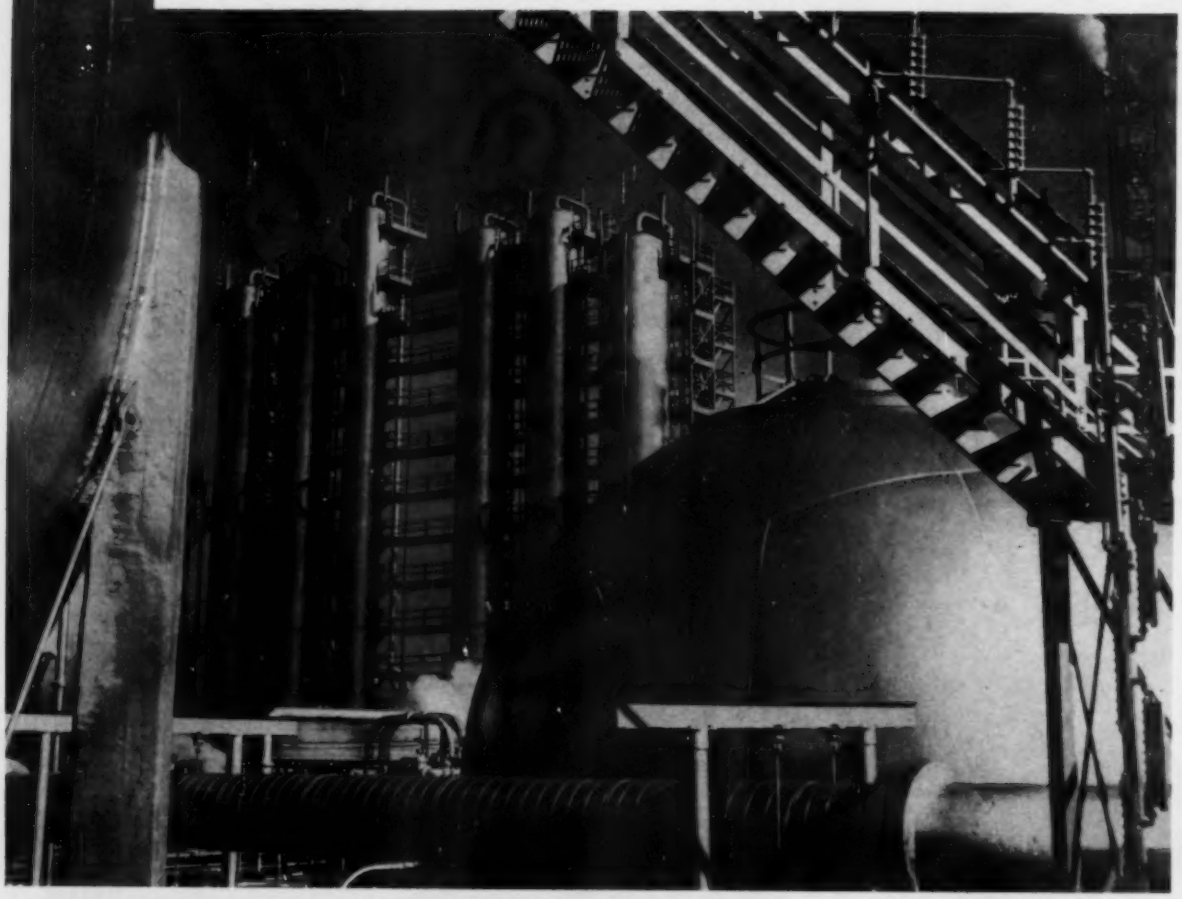
For more information, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

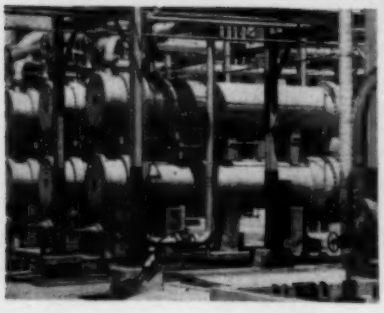
USS and "T-1" are registered trademarks

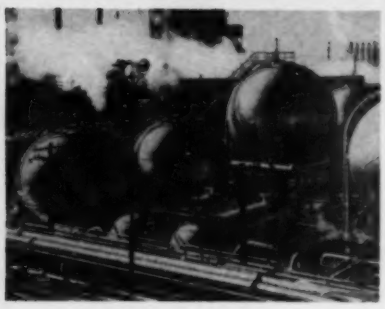
United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
National Tube Division – Pittsburgh
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Supply – Steel Service Centers
United States Steel Export Company

United States Steel

Here's what you can expect







RESULTS LIKE THESE:

Typical case histories tell the story of Oakite ECP's at work in various refineries. They helped:

- cut 3½ days, $2,250 from previous absorber turnaround time; knocked 5 days, $3,300 from reformer tower turnaround; put fouled catalytic reformer furnace back on-stream in 2 days.
- reduced tube bundle cleaning costs 70%; saved 8-year-old tube bundles from scrap heap.
- cut parts salvage operation from 22 hours to 1½ hours per batch.
- stripped paint from tank exterior in just a few hours; cleaned asphalt storage tank interior in 1½ days.

Ask the Oakite man to give you complete information, or send for these valuable bulletins. Write Oakite Products, Inc., 48 Rector Street, New York 6, N. Y.

from an Oakite ECP

engineered cleaning program

Savings in turnaround time, in money, man-hours, and maintenance—these are some of the things you can expect from an Oakite Engineered Cleaning Program. ECP takes a scientific approach to cleaning *through chemistry*. It is tailored specifically to suit your refinery, your equipment, your soils, your throughput. ECP gives you:

DETAILED RECOMMENDATIONS

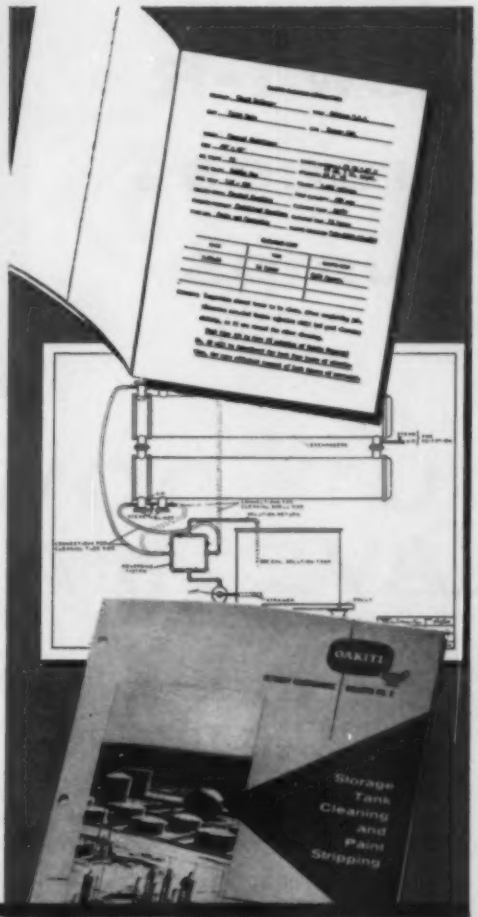
Specific cleaning recommendations—tower by tower, bundle by bundle—are outlined in a complete, written report. It includes estimated quantities of materials required, estimated off-stream time, step-by-step instructions for your crew. ECP utilizes time-saving mechanized and in-place cleaning wherever possible.

TECHNICALLY QUALIFIED AID

To implement the program, the Oakite man sticks with the job until your crew is fully oriented. He brings with him a background of practical refinery cleaning experience... coupled with materials and methods from the finest cleaning research laboratory in the country. In short, your Oakite man is expressly prepared to give you top efficiency, speed of operation *plus* low-cost end results.

ENGINEERING DRAWINGS, LITERATURE

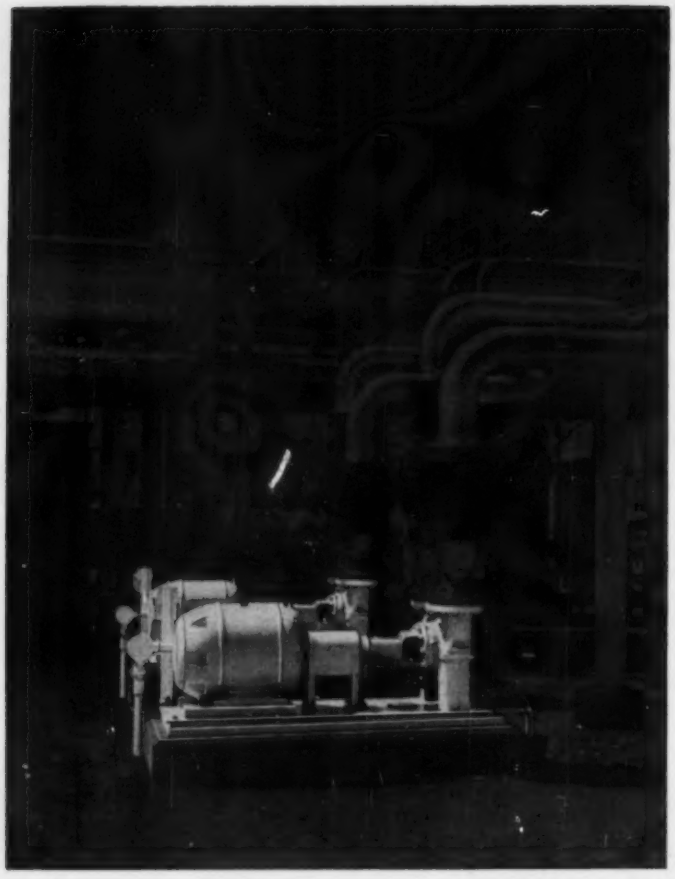
Engineering drawings of suggested equipment and pumping hook-ups are included in the ECP. And fact-filled literature that details cleaning procedures is made available.



OAKITE
over 50 years' leadership in industrial cleaning
Est. 1909
SCIENCE

ECP
your economy key

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



how I-R process pumps

CUT DOWN-TIME SAVE MAINTENANCE

RUGGED CASING for longer life. Centerline supported . . . recessed gasket for metal to metal fit . . . hydro-tested at twice the working pressure . . . generous corrosion allowance.

BALANCED ROTOR assures vibration-free operation. Hydraulic balance is attained by back ribs or back rings . . . Complete dynamic balance.

RIGID SHAFT prolongs seal and bearing life. Minimum deflection throughout the operating range . . . ground overall to final dimensions for close tolerance.

DEEP STUFFING BOX provides for effective sealing. Various packing arrangements depending on the service . . . mechanical seals can be engineered and applied to all pump sizes.

SPACER COUPLING simplifies maintenance. The pumping element and bearing housing can be removed as a single unit without disturbing the piping or driver.

For the complete story on I-R process pumps, contact your nearest I-R representative.

Ingersoll-Rand

100A10 11 Broadway, New York 4, N. Y.

COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

Solutizer Process

Licensed by: Shell Development Company

DESCRIPTION: The three essential steps of the process are caustic pretreatment, solutizer treatment, and regeneration. Caustic pretreatment is often necessary to remove acidic component such as hydrogen sulfide and, in some cases, to control the alkyl phenol concentration. A single conventional mixer-settler arrangement is usually satisfactory for this purpose, and the caustic solution may be used until it is essentially saturated. A coalescer follows the caustic settler to minimize contamination of the potassium hydroxide treating solution with sodium ion.

For mercaptan extraction the sour hydrocarbon feed is contacted with a suitable solutizer solution in counter-current flow. The extracting agent is strong potassium hydroxide solution containing mercaptan solubility promoters (solutizers) such as fatty acids; e.g., propionic and butyric acids, and/or alkyl phenols. The latter may be used if their concentration in the fraction treated is great enough to maintain the required solutizer strength in the treating solution.

In the past, mixer-settler units have been used for the mercaptan extraction step. However, in all new designs, the Shell Rotating Disc Contactor (RDC) has replaced mixer-settlers. Use of the new apparatus in this step of the process substantially reduces capital cost and adds significantly to operating flexibility.

The treated hydrocarbon flows from the extraction section to storage or subsequent operations. The spent treating solution is heated to 130 to 160 F., passes through a gasoline coalescer, and enters the regenerator where the extracted mercaptans are oxidized to disulfides by air blowing. This operation is accomplished in a column equipped with efficient air dispensers or in any standard liquid-gas mixing device. Dissolved and/or entrained disulfide oil is removed by a naphtha wash. The naphtha required is only 1 to 2 percent of the gasoline treating rate, and it may be disposed of by adding it to reforming or catalytic cracking charge stock. The regenerated solutizer is then cooled and returned to the extraction step.

No corrosion-resistant metals are required since operating temperatures are low and the treating solution in noncorrosive. Labor costs are low due to the simplicity of operation and adaptability to virtually complete automatic control. The solution is inexpensive and has an extended treating life, so that chemical cost is nominal. Exhaust steam can be used to fulfill the limited heating requirements.

APPLICATION:

For removing mercaptans from sour gasolines.

PRODUCT:

Mercaptan removal to the "odor sweet" level of 0.001 to 0.003 weight percent mercaptan sulfur is easily achieved when treating a wide range of straightrun or cracked stocks, either low-end or full-boiling-range gasolines.

SERVICE FACTOR: 95 percent.

UTILITIES	Per bbl Gasoline
Steam	4.2 lb
Cooling Water (30 F rise)	14.2 gal
Air	7.0 ft³
Power	0.12 kwhr

CHEMICALS	Per bbl Gasoline
KOH	0.030 lb
Alkyl Phenols	0.024 lb
Lime	0.045 lb

CAPITAL COST:

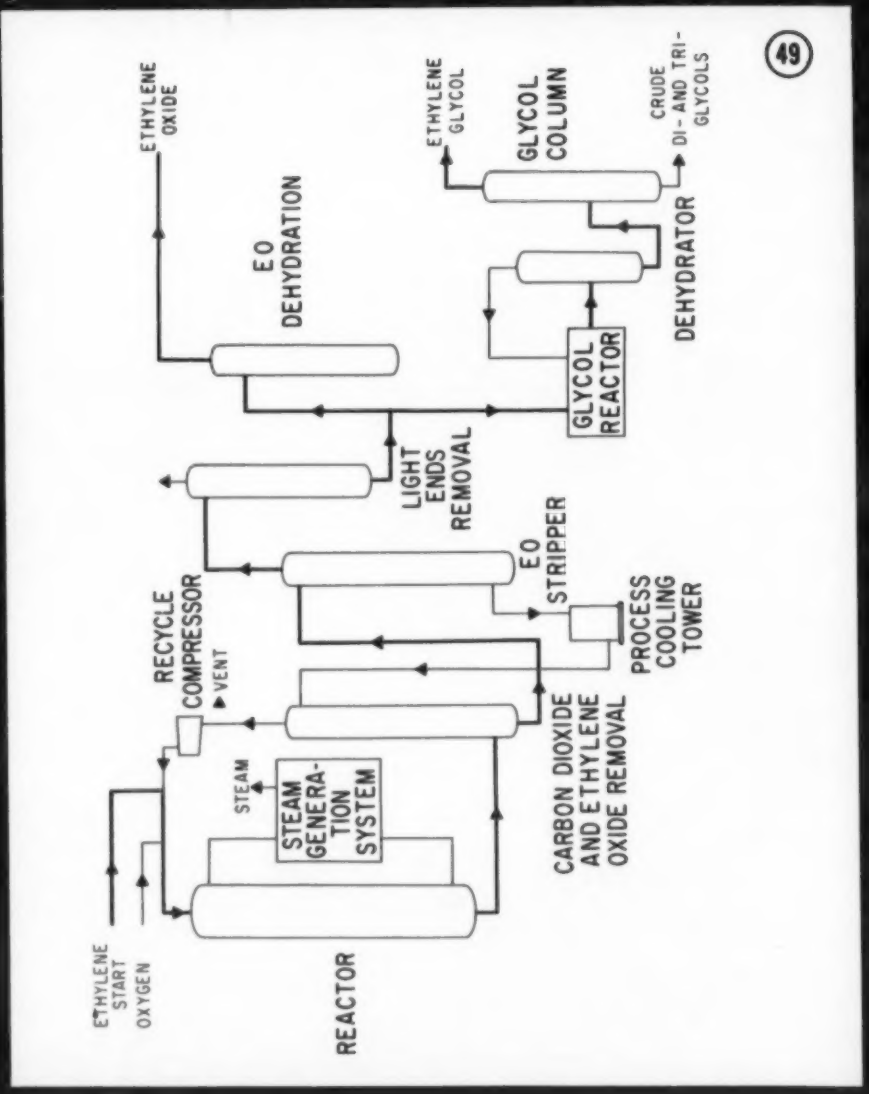
Bare equipment for 10,000 bbl/sd treater: $112,000

Operating Manpower: 1-1/2 men/shift

Maintenance: About 2 percent of installed plant cost per year.

Ethylene Oxide and Glycol

Licensed by: Shell Development Company



Ethylene Oxide and Glycol

Licensed by: Shell Development Company

DESCRIPTION: This Shell Development process produces ethylene oxide by direct oxidation of ethylene with oxygen. Use of 95 percent oxygen rather than air minimizes the vent loss of unreacted ethylene and improves the efficiency of the process. Product distribution between ethylene oxide and glycol can be varied over a wide range to suit customer requirements.

Ethylene and oxygen together with recycle gas are charged to a tubular isothermal reactor. The reaction takes place in the presence of a silver catalyst and proceeds according to the equation: $C_2H_4 + 1/2\ O_2 = C_2H_4O$. The heat of reaction is removed by a coolant, and the hot coolant is used to generate steam.

Ethylene oxide is recovered from the reactor effluent by absorption in water. Except for a small vent, the residual gases are compressed and recycled. The ethylene oxide is stripped from the "fat" water and distilled to remove light ends. The "lean" water is cooled in a process cooling tower before being returned to the absorber. Part of the raw ethylene oxide is dehydrated to produce finished ethylene oxide; the balance is reacted with excess water in a special reactor according to the equation: $C_2H_4O + H_2O = HOC_2H_4OH$. The resulting aqueous solution of ethylene glycol is dehydrated to produce anti-freeze grade ethylene glycol; industrial grade ethylene glycol and diethylene glycol also may be produced.

FEED STREAMS

Ethylene

Ethylene	98 percent minimum
Methane	1 percent maximum
Ethane	1 percent maximum
Acetylene	10 ppm maximum

Oxygen

Oxygen	90-95 percent
Nitrogen, Argon	Balance

UTILITIES

Various utility balances and types of prime drivers are possible depending on customer preferance, value of utilities, capital charges, etc.

PRODUCTS (TYPICAL SPECIFICATIONS)

Ethylene Oxide

Ethylene Oxide	99.7 %	minimum
Water	0.05%	maximum
Aldehyde as Acetaldehyde	0.03%	maximum
Acidity as Acetic Acid	0.01%	maximum
Non-Volatile Residue	0.02 g/100 ml	max.
Carbon Dioxide	0.01%	maximum
Color APHA	15	maximum

Ethylene Glycol (Industrial Grade)

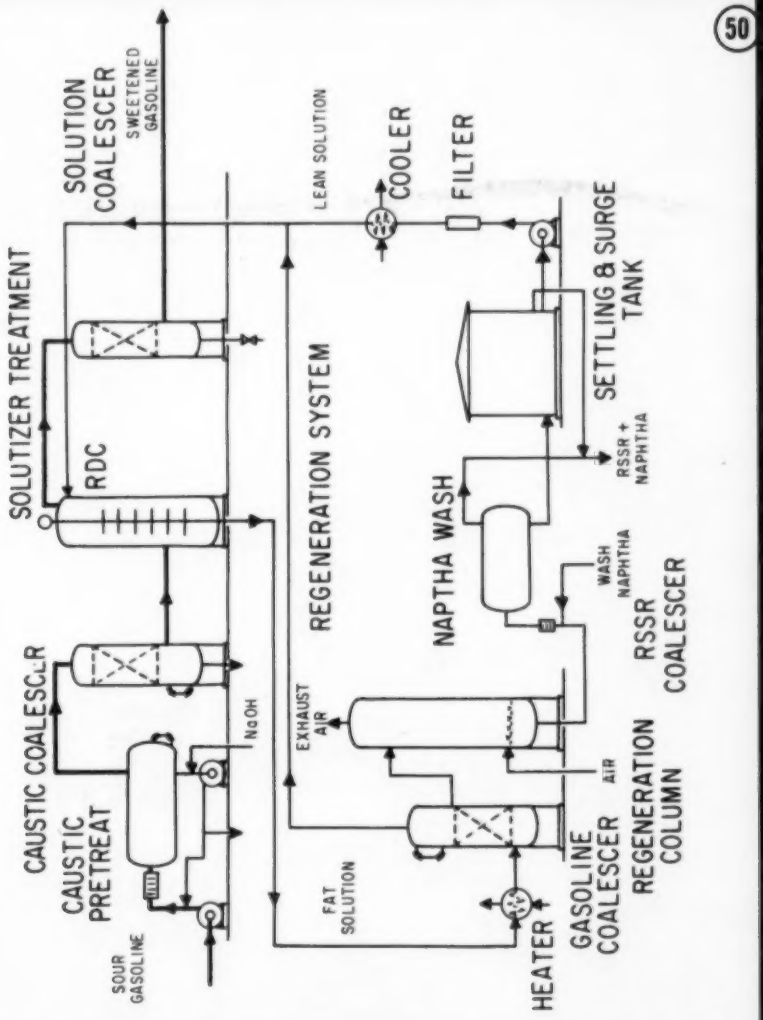
Ethylene Glycol	99.6%	minimum
Water	0.3%	maximum
Iron as Fe	0.15	ppm max.
Acidity as Acetic Acid	0.005%	maximum
Color APHA	10	maximum

CONTRACTORS

The Shell Development process for ethylene oxide is available through the following contractors: Badger Manufacturing Company; Catalytic Construction Company; The Fluor Corp., Ltd.; The M. W. Kellog Company; and The Lummus Company. Information on capital and operating costs for specific applications may be obtained from these contractors.

Solutizer Process

Licensed by: Shell Development Company



AMERICAN PETROLEUM INSTITUTE

"College of Refining"

A noted oil writer once compared the American Petroleum Institute to a vast educational machine, much like a university.

Commenting on the API's 20th annual meeting, held in November 1939, he wrote:

"When one goes wandering around to all these meetings to find out what is really going on, he may easily come of the opinion that he is searching into the the classrooms and laboratories of a great university. He will find doctors with all sorts of degrees, professors and ex-professors, engineers, chemists, and economists who are talking before charts, blackboards, moving picture screens, and even an assortment of laboratory equipment. There are lawyers and businessmen who run the details and look after the men and money of oil companies and manufacturing concerns, big and little, scattered over the United States and a fair part of the world."

Pursuing this image, we find the "university" to be headed by a president and administered by a board of trustees (directors). It is made up of five "colleges" — Production, Refining, Transportation, Marketing, and Finance and Accounting. Each has a "dean," an administrative staff, and a faculty which conducts research, classroom discussions, symposia, and convocations — the various research projects, committee meetings, divisional meetings, and general sessions, including, of course, the greatest convocation of all, the API annual meeting.

API's "College of Refining" deals with educational problems relating to virtually every phase of oil refining operations. These activities involve petroleum product improvement, refining technology, operating safety, improvement of refinery equipment, and personnel training.

The college also serves as a technical forum where "students" and "faculty" have the opportunity to exchange information on the application of general scientific developments to the art of refining petroleum. Some activities extend into areas of public interest, such as waste disposal and air cleanliness.

The College of Refining also has a research staff, the central abstracting service, which publishes API Technical Abstracts and API Abstracts of Soviet Petroleum Technology. This technically trained group selects and abstracts articles pertinent to the oil industry from about 150 periodicals published in the United States, the United Kingdom, France, Germany, and the USSR and its satellites.

In all, the college has 11 departments, whose activities, coupled with periodic classroom discussions and seminars, provide ample opportunity for members to give and receive information to improve refining operations.

Enrollment in the College of Refining is very restricted because of the high standards of the API. A student must be employed by an oil company, a resident of the United States, Canada, or Mexico, and recommended by his employer.

The faculty of each department is headed by a "professor" who directs the activities of the various "associate" and "assistant" professors. But here is no ivory-tower group. Each member of this faculty has had experience in the outside world of practical business, and most hold honorary degrees from the "University of Hard Knocks."

Meet the professors of the College of Refining:

college of refining

CLARENCE H. THAYER, *Sun Oil Company*

. . . executive head of the College of Refining, holds regular meetings of the board of regents (general committee). In these meetings all heads of departments of the college make reports covering conclusions reached in their respective seminars. Thayer, in turn, must consolidate the reports of his departments into a report of the college for presentation to the regents of the university (board of directors of API). By this process the where-with-all to sustain the college is obtained.

Thayer, who is vice president for manufacturing for Sun in Philadelphia, points out:

"A professor's direct contact with the commercial world helps make the college a part of our national life, and promotes the translation of the abstract into the practical."

DAN M. KRAUSSE, *Cosden Petroleum Corporation*

. . . heads the college's largest department, the Committee on Refining Equipment.

Seminars and symposia and the oil company officials who conduct them are:

Refinery inspections, J. K. Deichler, The Atlantic Refining Company; mechanical equipment, J. G. Housman, Standard Oil Company (Indiana); electrical equipment, E. R. Hoyle, Sinclair Refining Company; piping, J. P. Mooney, Humble Oil & Refining Company; instruments, G. N. Ehly, Atlantic; design and construction of pressure vessels, N. J. Rees, Socony Mobil Oil Company, Inc.; pressure-relieving systems, E. D. Underwood, Shell Oil Company; oil storage tanks, C. V. Lynn, Sinclair; corrosion, W. J. Sheridan, Esso Standard Oil Company.

Corollary to these, seminars and classes are held by these men associated with manufacturers and suppliers of refinery equipment:

Inspections, J. H. Rickerman, The M. W. Kellogg Company; valves, W. P. Kliment, Crane Company; safety and relief valves, L. P. Stillman, Minnesota Mining and Manufacturing Company; tanks and vessels, C. W. Wheatley, A. O. Smith Corporation; construction, R. N. Hancock, Foster Wheeler Corporation; mechanical drive turbines, W. J. Dugan, General Electric Company; heat exchangers, T. H. Miley, Foster Wheeler, and G. J. Robertson, Bechtel Corporation; gaskets, H. H. Dunkle, Johns-Manville Corporation; heater tubing, E. H. Palchik, The Lummus Company; centrifugal pumps, L. H. Garner, Worthington Corporation; centrifugal compressors, W. O. Lowell, Allis-Chalmers Manufacturing Company.

JERRY McAFEE, *Gulf Oil Corporation*

. . . is head of the Department of Smoke and Fumes. He is assisted by W. J. Coppoc, Texaco Inc., and G. A. Lloyd, Esso Standard Oil Company. Coppoc conducts regular seminars on the chemistry of air pollution and the composition of pollutants, while Lloyd holds seminars on education in pollution abatement.

The department maintains a continuing program of symposia on the nature of air pollution and its relationship to the oil refining industry.

J. C. DUCOMMUN, *Standard Oil Company (Indiana)*

. . . heads the new Operating Practices Department, formed as the result of a series of well attended symposia. Subjects treated here and the men in charge are:

Storage and handling of petroleum products, George C. Caine, Tidewater Oil Company; safety facilities, E. W. Griscom, Sinclair Refining Company, and safety in processing, F. H. Blunck, Standard of Indiana.

Addition of new curricula when needed is an important API service to furnish the refiner with a well-rounded educational program.

WAYNE E. KUHN, *Texaco Inc.*

. . . is head of the Department of Automotive Research. In addition to seminars conducted under his personal direction, the department also holds seminars on gasoline quality directed by J. B. Duckworth, Standard Oil Company (Indiana), and on detonation organized by J. J. Mikita, E. I. du Pont de Nemours & Company.

In order that the frontiers of knowledge in the development of better combinations of fuels, lubricants, and mobile land and airborne equipment may be shared with graduate students in equipment design, the API sustains jointly with the Society of Automotive Engineers a graduate extension school called Coordinating Research Council, Inc. Responsibility for supervising API's contributions, both intellectual and financial, to CRC, Inc., is vested in the Department of Automotive Research.

C. B. GALE, *American Oil Company*

. . . is in charge of the Department of Petroleum Products, the department around which the College of Refining grew up, developed, and proliferated. At one time it WAS the College of Refining. The growth of specialization and the ever-increasing complexities of refining sciences have brought about many changes that caused the creation of new departments, some of which are larger, and several of

which attract more attention. Subjects covered in the Department of Petroleum Products and the faculty members who specialize in them are:

Terminology, W. A. Myers, The Atlantic Refining Company; international standards, T. B. Rendel, Shell Oil Company; sampling taps, W. V. Cropper, Standard Oil Company (Indiana); physical constants of hydrocarbons, P. K. Kuhne, Gulf Oil Corporation; organization, classification, and retrieval of scientific information, L. E. Moody, Esso Research and Engineering Company; machine processing of scientific information, B. H. Weil, Esso Research and Engineering, and Rita Paddock, Atlantic.

Professor Paddock is the only woman faculty member.

E. Q. CAMP, *Humble Oil & Refining Company*

. . . heads the Department of Refinery Wastes, which for more than 30 years has collected, developed, and published information to help the refiner keep his waste inside the refinery fence. Topics dealt with by this department and the men in charge of them are:

Biological studies, L. C. Burroughs, Shell Oil Company; chemical wastes, R. J. Austin, Standard Oil Company (Indiana); oil-water separation, H. F. Elkin, Sun Oil Company; sampling and analysis, D. T. Quinn, Mobil Oil Company; solid wastes, A. D. McRae, Imperial Oil, Ltd.; waste gases and dusts, W. H. Lang, Esso Research and Engineering Company; dust collectors, E. N. Marsh, Standard Oil Company (Ohio); water quality, W. F. Meehan, Standard of Indiana.

WILLARD E. BENNETT, *Cities Service Oil Company*

. . . head of the Department of Education (Committees on Training), is assisted by J. A. Mawhinney, Jr., Shell Oil Company; J. J. Stadtherr, The Pure Oil Company; H. G. Abbott, Esso Standard Oil Company; D. S. Turner, Standard Oil Company (Ohio), and W. M. Read, The Atlantic Refining Company.

Regional graduate extension schools are directed in the East by W. S. Sedgwick, American Oil Company; in the Great Lakes area by J. R. Rosson, Ashland Oil & Refining Company; on the Gulf Coast by Hanford Hull, Continental Oil Company; in the Mid-Continent area by J. W. Gillen, Mobil Oil Company; in Northern California by R. A. Danse, Standard Oil Company of California, and in Southern California by L. G. Plank, Standard of California.

B. J. HEINRICH, *Phillips Petroleum Company*

. . . heads the Department of Analytical Research and lectures on analysis of petrochemicals.

Seminars on analytical chemistry are prepared by R. O. Clark, Gulf Oil Corporation, assisted by G. H. Patterson, E. I. du Pont de Nemours & Company, who organizes special roundtable discussions on analytical problems.

Other courses offered and the men who direct them are basic analytical chemistry, R. L. LeTourneau, California Research Corporation; analysis of petroleum fractions, J. H. Karchmer, Humble Oil & Refining Company, and analysis of refinery waste effluents, J. B. Rather, Jr., Socony Mobil Oil Company, Inc.

Graduate projects on metal organic standards and analysis of trace metals are led by C. M. Gambrill, Ethyl Corporation, and E. B. Tucker, Standard Oil Company (Indiana), respectively.

The course in analysis of catalysts is being reorganized, and Heinrich is seeking a qualified man to teach it.

W. S. PEELER, *American Oil Company*

. . . is in charge of cultural activities of the college. His Program Committee is responsible for organization and conduct of all symposia. This includes those sponsored by departments of the college, as well as those on subjects on which no seminars or classes are held. Peeler is well aware that the education of a refiner must embrace many more subjects than can be included in the formal curriculum of any graduate school. He and his associates go to great lengths to see that educational opportunities for refiners are furnished on the broadest possible base. The program of the midyear meetings of the division reflects his success in this direction.

A. P. FRAME, *Cities Service Oil Company*

. . . heads a special advisory committee that listens to the complaints and inquiries of department heads, conducts special assignments for the chairman of the refining division, administers a system of awards, watches the purse, and keeps the channels of communication open. When new departments are needed, Frame sees to their creation.

W. T. GUNN, *director of the API's Division of Refining*

. . . might well be compared to the dean of a college. He and his associates, J. D. Manney, E. H. Brenner, and R. R. Wright, are responsible for recording the sessions, scheduling meetings, keeping records, executing decisions, and maintaining services of the refining division. Gunn is responsible to the president of the API, the president of the refining division, and to all department heads.

For Successful Symposia and Seminars Sponsored by the College in 1959:

Now that you have met the faculty, here's a summary of projects the College of Refining sponsored during 1959:

WELDING RESEARCH COUNCIL

Pressure vessel research projects completed during 1959 included:

- Investigations of stresses in spherical and cylindrical vessels.
- Investigations of low-cycle plastic fatigue.
- Improved reinforced opening design.
- Effects of fabrication on steels for high temperature service.

Welding procedures project to evaluate pre-heating and stress-relieving was initiated.

CORROSION RESEARCH

At Louisiana State University some fundamental aspects of the chemistry of the reaction between iron (steel) and hydrogen sulfide were studied. Final paper based on the studies, a three-year project under Professor Paul Delahay, will be presented at the May meeting in Detroit.

At University of Wisconsin project was started at mid-year to study hydrogen attack on steel.

DUST COLLECTORS

University of Cincinnati completed a series of critical evaluations of published literature on dust collection devices. Covered were electrostatic precipitators, filters, wet collectors, and gravity, inertial, sonic, and thermal collectors.

GAS DIFFUSION

Project to provide a guide for use of gas diffusion equations in making air pollution surveys around refineries was completed. Aim of project was to disseminate knowledge of these complicated equations from the micrometerologists to the garden-variety engineer.

FERMENTATION STUDIES — WASTE WATERS

Dr. Charles E. Renn, Johns Hopkins University, carried out a study to determine feasibility of destroying taste and odor of water-borne refinery effluents by high temperature fermentation (thermophylic contact surface fermentation).

PHYSICAL CONSTANTS OF HYDROCARBONS

Dr. F. D. Rossini, Carnegie Institute of Technology, worked on selection of the most accurate physical constants of 632 hydrocarbons. Data will be presented in both English and metric units.

TRACE METALS ANALYSES

Three-year program was completed to develop instrumentation for more rapid and precise determination of trace metals in organic mixtures. A cyanogen-oxygen burner was developed which, coupled with any of several spectroscopes, quickly and accurately measures amount of metals in a specimen.

METAL-ORGANIC STANDARDS

Two-year program was completed to develop metal-organic standards for calibration of spectroscopes. Work was carried out at the Bureau of Standards with $36,000 in API funds advanced in 1957 and 1958. API support brought the program to a stage where the bureau can carry on without outside support.

ELECTROSTATICS OF AIRPLANE FUELING SYSTEMS

Project was started to develop safeguards against explosion of jet fuels in airplane fuel tanks during fueling and operation. Work is being done by Atlantic Research Corporation, Alexandria, Virginia, and is supported by the aircraft industry as well as the API through the Coordinating Research Council, Inc. (CRC, Inc.).

EQUIPMENT SURVEY

Annual survey of automotive equipment conducted in CRC, Inc., determined octane requirements of new automobile engines.

FUELS SURVEYS

Inspection data on fuels marketed in the United States were gathered by the Bureau of Mines and published in these reports:

- Two semi-annual surveys of automotive gasoline.
- Annual survey of aviation fuels.
- Annual survey of diesel fuels.
- Annual survey of burner fuels.

AIR POLLUTION RESEARCH

Studies were in progress at Franklin Institute, Wm. E. Scott and Associates, and University of California, Riverside. Significant developments in chemistry of urban air pollution included:

- Discovery that Compound X (peroxyacyl nitrate) is a powerful phytotoxicant (i.e., is poisonous to plants).
- Conclusion that sulfur dioxide must be present, even though in minute quantities, to trigger the cloud-forming reaction involving hydrocarbons, oxides of nitrogen, ozone, and sunlight called urban "smog."

Program of analysis of automobile exhaust was concerned in 1959 with developing instrumentation to provide the precise analysis required. Project was carried out under CRC, Inc., and financed by the automotive industry and API. Project is included in the 1960 program.

SAMPLING TAPS FOR OIL LINES

Preliminary results of engineering study at Purdue University indicate it might be possible to apply scientific principals to the location and design of sampling taps. * *

Division of Refining
25th Midyear Meeting
Sheraton-Cadillac and
Statler Hilton Hotels,
Detroit, Michigan
May 9-12, 1960

mathematics workshop

Dr. Joseph M. Marchello, author of *Petro/Chem Engineer's* forthcoming engineering mathematics review, is assistant professor of chemical engineering at Oklahoma State University, Stillwater. Since joining the OSU faculty in September 1959 he has taught both graduate and undergraduate courses in thermodynamics, mass transfer, and unit operations.

Marchello, whose research interests are in the fundamental aspects of mass transfer and unit operations, received his PhD degree from Carnegie Institute of Technology. His undergraduate work was at the University of Illinois.

He has worked for Du Pont in the separations engineering group at the Savannah River Laboratory, Aiken, South Carolina; with Rocketdyne, a division of North American Aviation, Canoga Park, California, and with the research department, combustion and lubrication division, Phillips Petroleum Company, Bartlesville, Oklahoma.

As an initial part of his graduate work at Carnegie Tech, Marchello published with H. L. Toor the article "Film-Penetration Model for Mass and Heat Transfer," which appeared in the April 1958 issue of the *Journal of the American Institute of Chemical Engineers*. This paper was the basis for his thesis work on turbulent mass and heat transfer.

Marchello is a member of the AIChE, the American Chemical Society, the Society of Sigma XI, and the American Rocket Society and is listed in the latest edition of American Men in Science.

Are you becoming technically obsolete?

If you have been out of college 10 years or more, chances are you have forgotten a good deal of the mathematics you studied in school.

Also, you may not be informed on recent mathematical developments that apply to your work as a practicing process or design engineer.

To bring you up to date, *Petro/Chem Engineer* will carry an engineering mathematics workshop by Dr. J. M. Marchello of the Oklahoma State University chemical engineering faculty starting in the June issue.

No "ivory tower" engineer, Marchello is well aware of the sort of problems you face. His series will be full of practical know-how to help you do a better job.

The series is not intended as a comprehensive treatise in applied mathematics. For the most part, theorems will be simply stated and their **applications** discussed **in detail.** However, enough theory will be included to show the basis and background of the methods, and adequate references will be given for readers who wish to dig deeper into any particular subject.

In the example problems emphasis will be placed on both formation of the physical problem and the mathematical principles involved.

In introducing the series, Marchello points out mathematical treatment of physical problems consists in general of three phases or processes.

1. Physical principles forming background of the problem are expressed mathematically by equations, which are symbolic statements of physical laws.
2. Equations are manipulated mathematically to obtain the desired relations among the variables.
3. New relations are interpreted to give additional information on the physical quantities.

Marchello will follow this mode of reasoning in his examples as he examines the branches of mathematics with which process and design engineers are most frequently concerned.

You'll want to save each issue for future reference in your Petro/Chem Modern Engineering Bookshelf.

FOR MAXIMUM SERVICE SPECIFY

B&W *Job-Matched seamless pressure tubing*

B&W offers you . . .

- sound engineering assistance on tubing end-use and fabricating requirements
- mutual understanding toward achieving the most satisfactory and economical tube performance
- the extensive facilities of 2 tube mills—plus a nationwide network of district sales offices and steel service centers manned by *experienced* tube salesmen—equipped to serve you with efficiency and dispatch

These are just a few of the many reasons why it pays to specify B&W Carbon or Alloy Seamless Pressure Tubing or Pipe. And remember—matching tubes to jobs assures you the *right tube,* in the *right quantity,* at the *right time.* For more information, call your local B&W District Sales Office, or write for Bulletin TB-417. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

TA-9055-SP2

B&W THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Part 12: Site Preparation

refinery construction manual

HENRY MARTYN NOEL, *New Canaan, Connecticut*

Construction Superintendent

The individual who is selected as construction superintendent for a refinery project is responsible for the expenditure of about 30 percent of its total job cost. Although he may have had nothing to say about whether or where the refinery should be built or what it should consist of, he does have a considerable influence on how much it will cost to build and how long it will be in building.

He is best appointed soon enough to be able to confer with the estimators and design men in the early stages of their work. He goes to the site as soon as he can for an advance appraisal of local conditions. When he arrives to stay for the duration he takes with him his heads of engineering, accounting, and field office administration — also some of his craft and labor general foremen; he also has a sheaf of blue prints showing the layout of the new work and as many of the plot plans and preliminary sketches as he can get.

Drawings will be arriving at the site throughout the construction period and in great numbers. It is probable that in remote places they will arrive as single, reproducible, copies. This means that photographic duplicating equipment should be installed at the site to supply the large number of copies needed.

An important function related to but not under the control of the field superintendent is that of shipping. Arrangements must be made at the site for receiving all materials and equipment and for unloading the very heavy items. Temporary wharfage and lighterage may have to be provided at the outset and special railway trackage for heavy items later on.

Site Clearance

The first thing the superintendent must do is to set up his office; in a new refinery job this means the construction of a substantial temporary building with heat, light, water and phones. He starts by buying local supplies of lumber and small pipe and hiring local help for the office construction and local help for making the other temporary buildings, roads and receiving areas. He writes to the home office to expedite his heavy construction equipment.

In more remote locations where there are no local supplies the problem of "setting up shop" is more complicated. All sorts of materials and even food and drink may have to be ordered and transported from a distant supply point.

A road system is surveyed and started in accordance with the refinery layout. A contractor is engaged to put down the piles for the dock and the railroad company is induced to run a spur to the new refinery warehouse site. A complete topographical survey is made if not already available and elevation markers are installed to guide the work of grading.

Applications are made to, and complicated negotiations are begun with, the river, road, railroad, electricity and telephone authorities and building inspectors.

Construction machines arriving at the site must be unloaded, conditioned and put into practice service by the untried operators obtained locally. An experienced man must be on hand to train the local help in the operation of the particular kinds of earth moving and lifting tools. The process areas are leveled and the permanent roads are graded and dry-surfaced for use until compacted. The truck traffic pattern is established so that materials and equipment can be received, unloaded and stored efficiently, convenient for withdrawal without obstructing the building operations.

As the grading of roads and their surfacing proceeds a temporary warehouse is constructed to house the cement and other perishable materials and tools. Temporary storehouses are among the first things to be built. Receiving and unloading facilities are also vitally important. Special precautions against pilferage are needed in some countries. The matter of warehousing must be well studied at the outset or it is apt to be a burden throughout the entire construction period.

Dock construction is usually in the hands of a local contractor but in any case must be supervised and expedited since the heaviest equipment will probably arrive by water. Test piles are put down and the penetration verified so that piles of the proper length can be specified. If the dock superstructure is to be of concrete a central concrete mixing plant may be built at the outset so as to be useful for the dock first and the foundations work later.

For the dock construction there must be a pile driver, either floating or shore based, to put down the temporary moorings or permanent dolphins and to put down the permanent pilings for the dock. For short piles wood is used but where the bearing value of the bottom is low and long piles must be used, these may be made of reinforced concrete of a special design to take impact. Such piles can sometimes be shipped in but more often must be poured at the site in their special steel shells. Other sorts of fireproof piling are available for particular cases.

In addition, a dredge of some kind is needed for the dock construction, except under favorable circumstances. This may be the clam shell type or the hydraulic type or the large continuous mechanical dredge. In any case its work is time-consuming and the dock work is likely to be held up for dredging.

As regards **construction equipment** in general, besides the pile drivers and the dredge and the concrete mixing plant, there will be needed immediately numerous flat bed

and dump trucks, excavators, and graders. As the work proceeds there will be need for a couple of crawler cranes and a guyed derrick or gin pole of about 150-ton capacity and 150 ft high. There will also be needed one or two air compressors and several air tuggers, two or three pipe machines and thirty to fifty 300-amp welding machines. The latter may be gasoline engine driven or if there is electric power already available, motor-driven.

This equipment usually arrives by water and the dock, temporary or permanent, must be adequate to handle such loads. Later on there will come across the dock vessels weighing up to a hundred tons each (or more) and boilers and turbo generators weighing forty or fifty tons apiece. Special long trailer trucks or railway flat cars will have to be accommodated on the dock to receive them. Space will have to be provided likewise for the receipt of great loads of tank plates, piping and structural steel.

Central concrete mixing plant involves elevated bins and hoppers for the cement, sand and gravel. It involves elevators and platforms and a large mechanical mixer driven by motor or gasoline engine. There must also be access by road, railroad and perhaps water for the receipt of the sand, gravel and cement and a good trucking road to the refinery units. Instead of a central mixing plant, served by dump trucks, it is often preferable to have a batching plant convenient to the source of materials and served by mix trucks. This usually involves less investment and may be more flexible.

Grading and leveling of the refinery area will amount to fifty acres for a small refinery, in addition to the roadways. The twelve small refineries around Ploesti, Rumania, averaged 100 acres apiece; a refinery of 50,000 bbl per day capacity usually occupies about 300 acres and a large refinery like Bayway extends over 1000 acres.

Not all of this land must be graded since a large part of it is simply space between tanks and space for expansion. Nevertheless, it is not unusual to move 100,000 yards of dirt for a modest refinery project. This is in addition to the road and railroad aggregate which must be brought in and laid in the approximate amount of 2000 cu yards for a 20,000 bbl per day refinery.

For a certain small refinery (16,000 bbl per day) where the common labor averaged one third as efficient as American, the temporary and permanent roads with their culverts were estimated to consume 640 man months of labor; the concrete mixing plant accounted for 110 man months; the temporary electric power and railroad facilities consumed 260 man months; the temporary buildings and other temporary construction consumed 70 man months. Since the entire refinery construction was estimated to require 24,000 man months it appeared that the land grading and dock together with the above items totaled nearly 10 percent of the total hours in the field.

The following table shows a typical schedule for the preliminary work in a small fuel refinery construction, assuming a normal set of circumstances and using common labor as efficient as American:

	Week No.*	Man Months	Men**	Special Equipment
Preliminary Survey	1–12	20	7	Instruments
Temporary office and shops	2–18	120	30	Power tools
Grading of site	4–16	100	30	Graders, excavators, trucks
Road construction	3–16	250	70	Dozers, rollers, trucks
Warehouse construction	3–14	90	30	Derrick, welders
Dock construction	4–35	320	40	Pile driver, dredge
Central concrete plant	4–8	20	20	Mixer, crusher, classifier, trucks
Temporary power	2–6	40	30	Transformer, generator
Miscellaneous	4–50	500	50	Trucks
Railroad connection	3–16	120	30	Dozers, trucks

*This column indicates which of the weeks, by order, following the arrival of the first construction group at the site, are involved in the items of work listed.

**This column indicates the *average* number of men, exclusive of the superintendent and his staff, engaged in the work listed during the period shown. The peak force might be twice the average.

Water Supply; Sewers

The availability of adequate supplies of fresh clean water for personnel and boilers and of salt or river water for process cooling and condensing was established before the refinery site was selected. The amount of fresh water is nominal, say 100 gal per day per employee, but the amount of process water required for a refinery is enormous.

As shown in the engineering chapter, the water requirement for a 25,000 bbl per day fuels refinery amounts to from 12,000,000 to 24,000,000 gal per day depending on its temperature.

This involves the use of several large pumps, say 5000 gal per min capacity each, and the use of a water main of 36-42-in. diam.

It sometimes involves the installation of a water intake box and screening mechanism in the ocean or in the river whereby the pumps may be protected from fish and waterborne solids.

Where water is scarce it may mean the construction of large wooden cooling towers with blowers and water recirculation.

Although all these considerations are the prime concern of the engineers, it often requires much ingenuity on the part of the field superintendent to execute the plans in a practical way. The grading of the refinery area will determine the changes in elevation required in the water line. There must be enough curvature allowed either vertically or horizontally, in laying long runs of straight pipe, so that expansion and contraction due to temperature changes will be taken up.

Except in the case of cast iron water pipe some protection against outside corrosion is required for underground lines. This usually means for pipe of 2-in. diam and over, that a coating of pipe enamel (special asphalt) is applied and then the pipe is wrapped with a fabric containing wire mesh to prevent abrasion against stones. The fabric covering is then painted with asphalt before the pipe is buried.

In the case of underground steel water lines (usually cement lined for salt water) they are put together with butt-welded joints and long lengths of pipe are assembled by welding at the side of the trench before being lowered. Special side-boom tractors are used for handling such piping in modern jobs, just as special trenching machines are best used for the excavation where the length of lines is great.

The pipe welders, able to weld in all positions, usually have to be trained on the job since several hundred of them are required when the yard piping work is in full swing. For any large underground water lines the pipe is supported at waist height on horses and assembled and wrapped in this position. In normal locations, where the water lines are laid upon concrete sleepers above ground, they are simply painted after welding in place.

The water pumphouse is placed as close to the water intake as possible in order to reduce or eliminate the suction piping. The water intake itself must be so placed as to avoid floating material as well as possible and its screens must be installed with an eye to easy access, repair and operation. Furthermore, a quiet zone for the intake position will sometimes mean a difference in silt content with great benefit to the pump impellers and to the maintenance of refinery water and sewer lines.

There is also a high pressure fire water system of piping separate from the main water supply, with connections for foam generators.

As regards sewers it is common to find the main sewer line 6 ft in diam in a refinery served by a 42-in. water line. This is most apt to occur in flat areas where the sewer fall may be as little as one inch or two per hundred feet. It re-

sults in a major job of excavation and here, in normal soil, the use of proper machinery is important.

Through rock there will be blasting and hand picking for the sewer lines or the use of open channels. Through areas of high ground water there will be used hundreds of sunken well-points to keep the ground water pumped away during excavation. In normal ground back hoes or shovels will be indicated for the large lines or a trenching machine when possible. The surveyor follows this work closely, setting the grade for the bottom of the trench.

The large sewers are normally constructed of concrete sections with the joints cemented, supported near the joints on solid pads. The sections of smaller diameter may be of vitrified tile, transite or cast iron pipe. The materials for this construction are readily obtained and it is normally undertaken early in the schedule before the equipment for the process units arrives at the site.

Another feature which is properly handled in connection with the sewer system is the sewer separator. This involves a considerable amount of excavation and concrete work. The earth moving machinery can take care of the dirt removal at the separator site in connection with the refinery ground clearance and grading. The carpenters can then build the form work and when the mixing plant is ready the concrete can be poured. The bottom of the separator is usually no more than ten feet below ground level and its size about 100 ft by 300 ft for a flow of 20,000,000 gal per day.

The main water pump house and the small separator pumphouse can both be constructed early in the schedule although the pumps and drivers and switch gear may not arrive for many months. Foundation bolts for this equipment may have to be placed after the pumphouses are built in order to get all this concrete work done before the general foundation work commences.

The man months consumed during the construction of the above mentioned 16,000 bbl per day fuels refinery, using much native labor, amounted to about 840 for the sewer system and nearly 600 for the cooling water system.

The major items of work on the sewer system were 180 man months for excavation, 180 for concrete work and 300 for the sewer line and separator piping. In this case the sewer was largely of concrete and vitrified pipe.

For the process cooling water system the main items of work were 400 man months for piping and 60 for concrete.

The scheduling of the water and sewer system construction depends very largely upon the procurement of the pipe and fittings. The work is gotten out of the way as soon as possible so that it will not interfere with the construction of process units later on and so that the pipe fitters and welders will not have both jobs to do at once. Furthermore, both the water and sewer facilities can be of use during the construction period, for example, in testing the tanks during erection.

The total period covered by this phase of the construction work may be six or eight months but the bulk of work should be concentrated in a four-month period starting two months after breaking ground. The average force using native labor, during the active period would total about 100 men for a small refinery's water supply and a like number for the sewer system. * * *

MOVING to a New Address?

If you are moving or expect possibly to move any time soon, save the coupon below for your convenient change of address. It will prevent your copy of Petro/Chem Engineer from being lost or mis-directed.

TO: Petro/Chem Engineer
P. O. Box 1589 • Dallas 21, Texas

Change my address, beginning with the_____issue

FROM: _____

_____

_____

TO: _____

_____

_____

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

performance tests?

. . . they can save you money

R. H. Parekh, an independent chemical engineering consultant in Dallas, Texas, is a native of Bombay, India, and is now a U. S. citizen. He holds a master's degree in chemical engineering from Massachusetts Institute of Technology and a bachelor's degree in chemistry from the University of Bombay. He is a registered professional engineer in chemical, petroleum and natural gas engineering for the State of Texas. His industrial experience as a practicing chemical engineer includes nearly 18 years in the natural gas department of Magnolia Petroleum Company, which recently merged into Mobil Oil Company. Prior to this he served for a year in the refinery research department of Bahrein Petroleum Company, Ltd., on the Persian Gulf. He is a member of the American Institute of Technology and the American Chemical Society and is a veteran of World War II.

▸ A GAS PROCESSING PLANT may cost up to a million dollars . . . or more . . . to construct. It may also cost several hundred thousand dollars a year to operate. In view of this, the cost of conducting performance tests to determine whether the plant is operating properly is neither a serious nor a major cost item. As shown in Table 8, it may cost between one and two thousand dollars to check its performance. Failure to conduct these tests properly and with qualified engineers may mean that you are not getting the MAXIMUM POSSIBLE PROFIT from your plant.

Here is a case history of a primary gas absorber containing 20 perforated trays. This is only a part of a complete evaluation of an absorption type natural gasoline plant. Actually two tests were made. One test was made soon after plant start-up to check the process design basis and to check the accuracy of the process design calculation methods. The second test was conducted to determine cause of the poor performance experienced after an 80 percent increase in oil circulation rate. This discussion of these two tests will clearly show:

- the importance and necessity of making performance tests.
- why a primary absorber can lose nearly 2000 gal per day more of butane and heavier hydrocarbons in residue with 80 percent increase in absorption oil rate.
- why the proper functioning of the absorption and stripping systems are dependent on each other.
- the importance and need for adopting a standard procedure for calculating gas absorber tray efficiency.
- a method for estimating absorption oil vaporization loss in the residue gas stream.
- a cost estimate for conducting a typical performance test.

During Test 1, it was found that the recovery of liquefiable hydrocarbons can be improved by increasing the absorption oil circulation rate to the primary absorber. It was also calculated that the perforated tray efficiency with respect to the key component (propane) was approximately 40 percent, (see Table 4).

After Test 1, the circulation rate over the primary absorber had been increased to nearly 80 percent more than in Test 1. An analysis of the residue gas was made at the plant using a portable chromatograph. This showed an unusually high loss of propane and C_4 + hydrocarbons. Calculations then indicated that the plant was losing nearly 2000 gal per day of recoverable liquids. A rough calculation of tray efficiency, assuming the absorption oil was completely stripped, gave a value of 15 percent.

What was the reason for this poor performance?
To find it out, Test 2 was performed. It therefore became necessary to

. . . procure representative test samples and test operating data with accuracy.

. . . get accurate component analysis of the test samples.

. . . select and apply fundamentally correct process design methods (which will take into consideration all factors encountered in the actual operation of the equipment studied).

The absorber fluid stream analyses and operating data for both performance tests are given in Table 1. The results of ASTM distillation for absorption oil are in Table 2. The calculation steps for the system absorption oil (broken down into 50 F apart normal boiling range cuts) are given in Table 3.

Residue gas analyses for Test 2 (Table 1) were conducted by mass spectrometer and chromatograph and are in very close agreement. This then eliminates the question of a major error in the residue gas analysis by the portable chromatograph.

By examining Table 1 two major differences are noted in absorber operating conditions. They are in absorption oil rate and absorption oil solute concentration. The degree of solute concentration at times is also referred to as lean oil or absorption oil saturation. For Test 2, absorption oil rate is approximately 80 percent greater than Test 1. And the extent of solute concentration is about 3 mole percent larger.

ASTM distillation result of system absorption oil for all practical purposes represents information about the solvent portion of absorption oil. Since the solvent portion of absorption oil is a multi-component mixture of heavy hydrocarbons, it is advisable to convert it into 50 F apart cut-components. Table 3 presents calculation steps for the breakdown of system oil into 50 F apart normal boiling range cuts using Universal Oil Products Characterization Factor and molecular weight vs density curves of the various cut-components. (Fig. 1.)

Absorption oil is broken down into cuts of average molecular weight by some process design engineers, and they are designated as Cut-C10, Cut C-11, etc. Here Cut-C10 represents a petroleum fraction which has an average molecular weight equal to molecular weight of normal paraffin decane. The basic idea in either case is to use these cut components with appropriate K-values for absorption oil vaporization loss and stripping still system calculations. A set of curves for 50 F apart cut components for absorption oil vaporization loss estimation are presented as Fig. 2, 3 and 4.

METHOD FOR PERFORMANCE EVALUATION

The calculations of primary absorber performance evaluation by including the existing amount of solutes in absorption oil for Tests 1 and 2 are given in Table 4 and Table 5 respectively.

TABLE 2. System Absorption Oil ASTM Distillation Results.

Percent distilled	Test 1 Temp., F	Test 2 Temp., F
Initial B. Pt.	364	154
5	428	432
10	438	455
20	445	464
30	451	472
40	457	478
50	465	484
60	476	493
70	482	501
80	493	511
90	510	531
95	526	567
End pt.	554	600
Residue	1.4	3.0
Recovery	98.5	97.0
Loss	0.1	0.0
°API at 60 F	41.8	40.3
Calculated mol. wt.	191	201
Calculated gal/mol	28.07	29.20
U.O.P. Characterization factor*	11.93	11.91

$$*\text{U.O.P. Characterization Factor} = \frac{(\text{Mean Average B. Pt. °R})^{1/3}}{\text{Sp. Gr. @ 60 F}}$$

TABLE 1. Primary Absorber Performance Tests — Fluid Stream Analyses and Operating Data.

	TEST 1				TEST 2						
Fluid stream	Gas in	Gas out	Oil in	Oil out	Gas in	Gas in	Gas out	Gas out	Oil in	Oil out	Oil out
Method of analysis	Low temp. fract.	Mass spec-trometer	Low & high temp. fract.	Calculated compo-sition	Mass spec-trometer	Chroma-tograph	Mass spec-trometer	Chroma-tograph	Low & high temp. fract.	Calculated compo-sition	Low & high temp. fract.
Component:	Mole%				Mole %						
CO_2	0.11	0.12	—	0.02	0.10	0.19	0.07	0.21	—	0.09	—
N_2	3.23	3.56	—	0.15	3.13	3.53	3.47	4.07	—	0.30	—
C_1	85.45	89.99	1.28	17.98	85.11	84.26	90.27	89.16	1.33	16.93	10.54
C_2	5.97	5.07	0.10	5.20	6.44	6.72	5.12	5.49	0.48	4.87	4.95
C_3	2.96	1.22	0.04	6.77	3.07	3.17	0.88	0.88	1.40	6.17	5.95
iC_4	0.38	0.02	0.02	1.31	0.45	0.41	0.06	0.05	0.27	1.09	1.24
nC_4	1.00	0.02	0.08	3.61	0.98	0.96	0.08	0.10	0.81	2.61	4.43
iC_5	0.24	—	0.06	0.92	0.24	0.21	0.03	0.02	0.18	0.61	1.35
nC_5	0.29	—	0.06	1.10	0.26	0.27	0.02	0.02	0.10	0.61	1.51
C_6+	0.37	—	0.16	1.42	0.22	0.28	—	—	0.19	0.63	69.03
Cut 400 F	—	—	6.76	4.23	—	—	—	—	4.62	3.21	—
Cut 450 F	—	—	55.14	34.55	—	—	—	—	29.77	14.41	—
Cut 500 F	—	—	31.32	19.62	—	—	—	—	55.06	40.29	—
Cut 550 F	—	—	4.98	3.12	—	—	—	—	11.79	8.18	—
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
C_6 (+) mol. wt.	93.60	—	—	—	90.60	—	—	—	—	—	—
C_6 (+) gal/mole	16.29	—	—	—	15.76	—	—	—	—	—	—
Pressure, psig	515	—	—	—	505	—	—	—	—	—	—
Temp. F	71	85	78	91	79	79	80	80	72	88	88
Vol, Mscfd	46,018	41,264	—	—	46,156	46,156	39,885	39,885	—	—	—
Vol, gal/min.	—	—	404	484	—	—	—	—	735	832	—
Mol. wt.	19.3	17.5	188	131	—	—	—	—	193	144	—
Density, API @ 60 F	—	—	41.8	55.2	—	—	—	—	40.3	51.0	—

In preparing Table 4 and Table 5, the following algebraic equation for absorption design has been used:

$$\frac{Y_1 - Y_0}{Y_1 - \left[\frac{K\Sigma Y_0 X_0}{1+\Sigma X_0}\right]} = \frac{\left[\frac{L+(1+\Sigma X)}{KG\Sigma Y}\right]^{n+1} - \left[\frac{L+(1+\Sigma X)}{KG\Sigma Y}\right]}{\left[\frac{L+(1+\Sigma X)}{KG\Sigma Y}\right]^{n+1} - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

X = moles of one solute per mole of solvent
Y = moles of solute in gas phase per mole of inlet gas
L = liquid rate as moles of solute free solvent per unit time
G = gas rate as moles of inlet gas per unit time
ΣY = summation of the values of Y for each component
ΣX = summation of the value of X for each component, except the solvent present in the liquid phase. X is unity for the solvent
K = equilibrium ratio at system temperature, pressure, and composition = y/x
n = number of theoretical trays

Subscripts 1 and 0 refer to the rich and lean end of the absorber, respectively.

The left term in the above equation represents the efficiency of absorption, and it is designated by the symbol E_a. The term $\frac{L+(1+\Sigma X)}{KG\Sigma Y}$ is defined as the absorption factor and is designated by the symbol, A. By substituting

TABLE 3. System Absorption Oil Break-Down into 50 F Apart Normal Boiling Range Cuts. Basis: 100 gal system absorption oil.

Calculation Steps	1	2	3	4	5	6	7	8	9	10	11	12
	U. O. P "K"	Cut boiling range, F	Average boiling pt. R	R½	Specific gravity at 60 F	API gravity at 60 F	Lb/gal	Gal	Lb	Mole wt.	Moles	Mole fraction
Cut component												
Test 1												
Cut 400 F	11.93	I.B.P. to 425	860	9.51	0.7972	46.1	6.64	6	40	163	0.245	0.0688
Cut 450 F	11.93	425 to 475	910	9.69	0.8122	42.7	6.77	54	366	183	2.000	0.5615
Cut 500 F	11.92	475 to 525	960	9.86	0.8265	39.7	6.88	34	234	206	1.136	0.3189
Cut 550 F	11.93	525 to E. pt.	1010	10.03	0.8407	36.8	7.00	6	42	232	0.181	0.0508
Total	—	—	—	—	—	—	—	100	682	—	3.562	1.0000
Test 2												
Cut 400 F	11.91	I.B.P. to 425	—	9.51	0.7985	45.7	6.65	4	27	163	0.166	0.0485
Cut 450 F	11.91	425 to 475	—	9.69	0.8136	42.4	6.78	20	136	182	0.747	0.2181
Cut 500 F	11.91	475 to 525	—	9.86	0.8279	39.4	6.90	62	428	205	2.088	0.6096
Cut 550 F	11.91	525 to E. pt.	—	10.03	0.8421	36.5	7.01	14	98	231	0.424	0.1238
Total	—	—	—	—	—	—	—	100	689	—	3.425	1.0000

TABLE 4. Primary Absorber Performance Evaluation for Test 1.

Calculation Steps	1	2	3	4	5	6	7	8	9	10	11	12
	Gas in	Oil in	Gas out	Oil out	Absorbed hydrocarbons	Top tray equilibrium ratio	Solute in abs. O. correc. term	Absorption efficiency	Bottom tray equilibrium ratio	Absorption factor	Number of theoretical trays	Absorber tray efficiency
Component:	mols/d	mols/d	mols/d	mols/d	mols/d	K @ 530 Psia 85F	mols/d	E_a	K @ 530 Psia 91F	A	n	percent
CO_2	137	—	130	7	7	3.100	—	0.0511	3.150	0.0899	—	—
N_2	3,916	—	3,866	50	50	18.000	—	0.0128	18.000	0.0157	—	—
C_1	103,474	269	97,719	6,024	5,755	7,400	10,286	0.0618	7.500	0.0377	—	—
C_2	7,227	21	5,505	1,743	1,722	1.270	138	0.2429	1.320	0.2144	—	—
C_3(Key)	3,585	8	1,325	2,268	2,260	0.420	18	0.6336	0.440	0.6433	8	40
iC_4	457	4	22	439	435	0.190	4	0.9603	0.200	1.4152	6	30
nC_4	1,215	17	22	1,210	1,193	0.140	12	0.9917	0.150	1.8869	—	—
iC_5	294	13	—	307	294	0.062	4	1.0138	0.067	4.2245	—	—
nC_5	355	13	—	368	355	0.048	3	1.0085	0.052	5.4431	—	—
C_6+	441	34	—	475	441	0.010	2	1.0046	0.011	25.7000	—	—
Cut 400 F	—	1,419	—	1,419	—	0.000220	1.62					
Cut 450 F	—	11,576	—	11,576	—	0.000051	3.05					
Cut 500 F	—	6,576	—	6,576	—	0.000016	0.54					
Cut 550 F	—	1,045	—	1,045	—	0.000005	0.03					
Total	121,101	20,995	108,589	33,507	12,512							
lb/d	2,330,968	3,958,101	1,903,474	4,385,595								
gal/d	—	581,760	—	694,880								
Mscf/d	46,108	—	41,264	—								
C_4 (+) loss, gal/d	—	—	536	—								
Absorber oil vapor loss, gal/d	—	—	102	—								
Absorber oil circ., gal/Mscf	—	12.62	—	—								
Absorbed HC heavier than key component					2,718							
Absorbed HC lighter than key component					7,534							

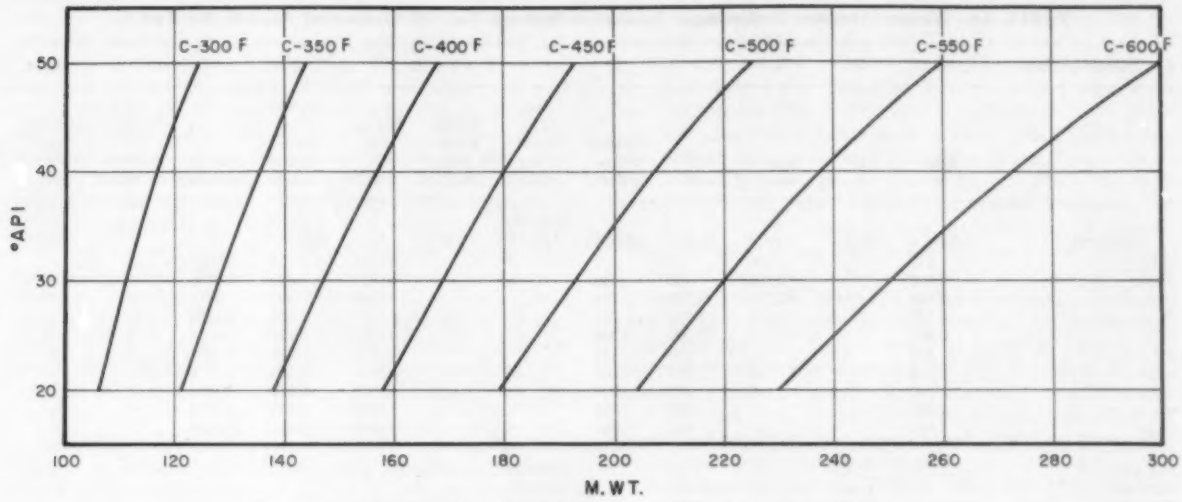


FIG. 1. Density vs molecular weight for various boiling range fractions.

the above, Equation 1 is written in a simpler form as follows:

$$E_a = \frac{(A)^{n+1} - (A)}{(A)^{n+1} - 1} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The term $Y_1 - Y_o$ for any component represents the amount of that component absorbed by the solvent. The term $\frac{K\Sigma Y_o X_o}{1 + \Sigma X_o}$ provides a correction factor for the presence of solute in the incoming solvent. In order to evaluate this term, it is necessary to know the equilibrium ratio (K) at the top tray temperature and pressure, total moles of residue gas (ΣY_o), and the mole fraction of the same component $\frac{X_o}{1 + \Sigma X_o}$ in the incoming solvent.

The term of absorption factor, A, contains three variables: the liquid rate (rich oil) $L + (1 + \Sigma X)$ leaving a tray, the gas rate $G\Sigma Y$, leaving the same tray, and the equilibrium ratio, K, at the pressure, temperature and composition conditions existing on the same tray. The component having an absorption factor closest to unity is defined as the "Key Component."

In the derivation of Equation 1, one of the assumptions

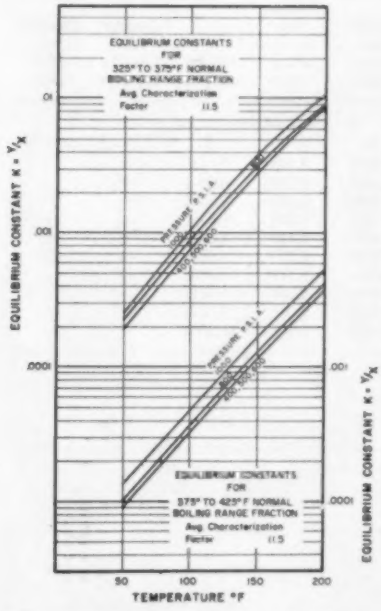


FIG. 2. Equilibrium constants for Cut-350 F and Cut-400 F.

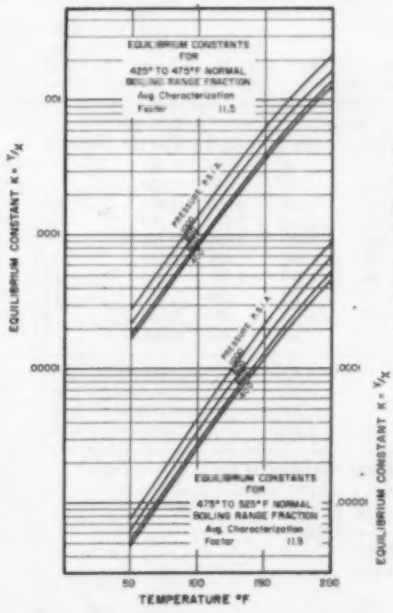


FIG. 3. Equilibrium constants for Cut-450 F and Cut-500 F.

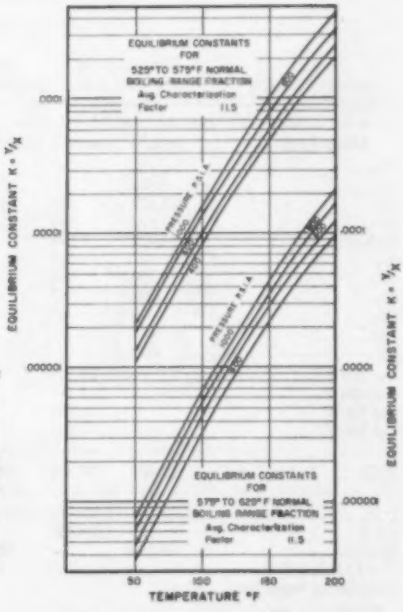


FIG. 4. Equilibrium constants for Cut-550 F and Cut-600 F.

TABLE 4A. Primary Absorber Performance Evaluation Without Abs. Oil Component Analysis for Test 1.

Calculation Steps	1	2	3	4	5	6	7	8	9	10	11	12
	Gas in	Oil in	Gas out	Oil out	Absorbed hydrocarbons,	Top tray equilibrium ratio	Solute in abs. O. correc. term	Absorption efficiency	Bottom tray equilibrium ratio	Absorption factor	Number of theoretical trays	Absorber tray efficiency
Component:	mols/d	mols/d	mols/d	mols/d	mols/d	K @ 530 Psia 85F	mols/d	E_a	K @ 530 Psia 91F	A	n	percent
CO_2	137	—	130	7	7	—	—	0.0511	3.150	0.0891	—	—
N_2	3,916	—	3,866	50	50	—	—	0.0128	18.000	0.0156	—	—
C_1	103,474	—	97,719	5,755	5,755	—	—	0.0556	7.500	0.0374	—	—
C_2	7,227	—	5,505	1,722	1,722	—	—	0.2383	1.320	0.2170	—	—
C_3	3,585	—	1,325	2,260	2,260	—	—	0.6304	0.440	0.6381	8	40
iC_4	457	—	22	435	435	—	—	0.9519	0.200	1.4038	6	30
nC_4	1,215	—	22	1,193	1,193	—	—	0.9819	0.150	1.8718	—	—
iC_5	294	—	—	294	294	—	—	1.0000	0.067	4.1904	—	—
nC_5	355	—	—	355	355	—	—	1.0000	0.052	5.3992	—	—
C_6+	441	—	—	441	441	—	—	1.0000	0.011	25.5000	—	—
Cut 400 F	—	1,426	—	1,426	—	0.000220	1.64					
Cut 450 F	—	11,637	—	11,637	—	0.000051	3.11					
Cut 500 F	—	6,609	—	6,609	—	0.000016	0.55					
Cut 550 F	—	1,053	—	1,053	—	0.000005	0.03					
Total	121,101	20,725	108,589	33,237	12,152							
lb/d	2,330,968	3,967,759	1,903,474	4,395,253								
gal/d	—	581,760	—	694,880								
Mscf/d	46,108	—	41,264	—								
C_4(+) loss, gal/d	—	—	536	—								
Absorber oil vapor loss, gal/d	—	—	102	—								
Absorber oil circ. gal/Mscf.	—	12.62	—	—								
Absorbed HC heavier than key component					2,718							
Absorbed HC lighter than key component					7,534							

TABLE 5. Primary Absorber Performance Evaluation for Test 2.

Calculation Steps	1	2	3	4	5	6	7	8	9	10	11	12
	Gas in	Oil in	Gas out	Oil out	Absorbed hydrocarbons	Top tray equilibrium ratio	Solute in abs. O. correc. term	Absorption efficiency	Bottom tray equilibrium ratio	Absorption factor	Number of theoretical trays	Absorber tray efficiency
Component:	mols/d	mols/d	mols/d	mols/d	mols/d	K @ 530 Psia 80F	mols/d	E_a	K @ 520 Psia 88F	A	n	percent
CO_2	121	—	73	48	48	3.100	—	0.3967	3.150	0.1438	—	—
N_2	3,802	—	3,642	160	160	18.500	—	0.0421	18.500	0.0245	—	—
C_1	103,377	498	94,747	9,128	8,630	7.800	10,889	0.0933	7.900	0.0573	—	—
C_2	7,822	180	5,374	2,628	2,448	1.250	630	0.3404	1.320	0.3431	—	—
C_3(Key)	3,729	524	924	3,329	2,805	0.410	602	0.8970	0.440	1.0293	8	40
iC_4	547	101	63	585	484	0.180	51	0.9758	0.200	2.2644	4	20
nC_4	1,190	303	84	1,409	1,106	0.132	112	1.0260	0.147	3.0807	—	—
iC_5	292	67	32	327	260	0.059	11	0.9253	0.066	6.8617	—	—
nC_5	316	37	21	332	295	0.045	5	0.9486	0.050	9.0574	—	—
C_6+	267	71	—	338	267	0.009	2	1.0075	0.011	41.2000	—	—
Cut 400 F	—	1,728	—	1,728	—	0.000200	0.97					
Cut 450 F	—	7,771	—	7,771	—	0.000045	0.98					
Cut 500 F	—	21,721	—	21,721	—	0.000014	0.87					
Cut 550 F	—	4,411	—	4,411	—	0.000004	0.05					
Total	121,463	37,412	104,960	53,915	16,503							
lb/d	2,333,367	7,241,182	1,835,358	7,739,191								
gal/d	—	1,058,400	—	1,198,643								
Mscf/d	46,156	—	39,885	—								
C_4 (+) loss, gal/d	—	—	2,518	—								
Absorber oil vapor loss, gal/d	—	—	59	—								
Absorber oil circ., gal/Mscf	—	22.93	—	—								
Absorbed HC heavier than key component					2,412							
Absorbed HC lighter than key component					11,286							

made is that the absorption of all components takes place simultaneously on a tray in an absorber. Actually, in a countercurrently operated gas absorber, the absorption of various components takes place in succession. The driving force for absorption in an absorber is directly proportional to the difference between the partial pressure of a component in the gas stream and the equilibrium vapor pressure of the same component in solution with the solvent. For the components more volatile than the key component, the driving force is greater at the lean end of the column. The absorption of these components, therefore, takes place in the top section of the absorber. For the components heavier than the key component, the driving force for absorption is larger at the rich end of the column. Absorption of these components therefore, takes place in the bottom section of the absorber. The driving force for the key component extends nearly throughout the entire absorber, and therefore absorption of key component takes place throughout the absorber.

On the basis of this, it is seen that all trays in an absorber are not being utilized by components lighter and heavier than the key component.

It is only for the absorption of the key component that all trays in an absorber are required. Because of this fact, an absorber tray efficiency value has true meaning only when it is calculated with reference to the key component under the existing operating conditions.

On a theoretical basis, in general, it can be concluded that for components lighter and heavier than key component, an absorber tray efficiency value would be smaller than that for the key component.

In calculating the absorption factor given in Tables 4 and 5, "K" values for the bottom tray at 5000 psia convergence pressure are used, and also the gas rate leaving the bottom tray is estimated by subtracting the amount of absorbed butane (+) components from the inlet gas rate.

It will be observed from Tables 4 and 5 that absorber tray efficiency with propane as the key component has remained nearly the same for both Test 1 and Test 2.

A comparison of solute in the absorption oil correction terms of Test 1 and Test 2 in Tables 4 and 5 reveals an explanation for loss of butane (+) of nearly 2000 gal a day more for Test 2. **(At a price of four cents a gallon, this loss will be equal to nearly $29,000 a year.)** The cause of this unusually heavy loss of butane (+) is due to the high concentration of these solutes in the system absorption oil. What it indicates is that the poor performance of the primary absorber during Test 2 was not due to any malfunctioning of the absorber but was due to improper operation of the stripping still system. In order to provide a confirmation of this conclusion, a comparison of stripping still operating data for Tests 1 and 2 is given in Table 6. To increase plant profits according to Test 2 evaluation, will require correcting the operation of the stripping still system.

Tables 4A and 5A are prepared to show the effect of neglecting solute in the absorption oil correction term upon an absorber performance evaluation.

A comparison between Table 4 and Table 4A shows that when the value of the correction term is small, the results of absorber performance evaluation are not much different.

TABLE 6. Stripping Still System Operating Data.

	Test 1	Test 2
Pressure, psig	165	160
Temperature, F		
Rich oil from heater outlet	470	442
Abs. oil from still bottom	453	416
Vapor from still top	176	189
Flow rates		
Rich oil to still—gal/min	585	814
Abs. oil from still—gal/min	448	735
Reflux to still—gal/min	216	154
Steam to still—lb/hr	4600	2300
Lb steam/gal abs oil	0.171	0.053

TABLE 5A. Primary Absorber Performance Evaluation Without Abs. Oil Component Analysis for Test 2.

Calculation Steps	1	2	3	4	5	6	7	8	9	10	11	12
	Gas in	Oil in	Gas out	Oil out	Absorbed hydrocarbons	Top tray equilibrium ratio	Solute in abs. O. correc. term	Absorption efficiency	Bottom tray equilibrium ratio	Absorption factor	Number of theoretical trays	Absorber tray efficiency
Component:	mols/d	mols/d	mols/d	mols/d	mols/d	K @ 520 Psia 80F	mols/d	E_a	K @ 520 Psia 88F	A	n	percent
CO_2	121	—	73	48	48	—	—	0.3967	3.150	0.1407	—	—
N_2	3,802	—	3,642	160	160	—	—	0.0421	18.500	0.0240	—	—
C_1	103,377	—	94,747	8,630	8,630	—	—	0.0835	7.900	0.0561	—	—
C_2	7,822	—	5,374	2,448	2,448	—	—	0.3130	1.320	0.3357	—	—
C_3(Key)	3,729	—	924	2,805	2,805	—	—	0.7522	0.440	1.0070	3	15
iC_4	547	—	63	484	484	—	—	0.8848	0.200	2.2155	2	10
nC_4	1,190	—	84	1,106	1,106	—	—	0.9294	0.147	3.0142	—	—
iC_5	292	—	32	260	260	—	—	0.8904	0.066	6.7135	—	—
nC_5	316	—	21	295	295	—	—	0.9335	0.050	8.8618	—	—
C_6+	267	—	—	267	267	—	—	1.0000	0.011	40.3000	—	—
Cut 400 F	—	1,758	—	1,758	—	0.000200	1.02					
Cut 450 F	—	7,906	—	7,906	—	0.000045	1.03					
Cut 500 F	—	22,096	—	22,096	—	0.000014	0.91					
Cut 550 F	—	4,487	—	4,487	—	0.000004	0.05					
Total	121,463	36,247	104,960	52,750	16,503							
lb/d	2,333,367	7,291,623	1,835,358	7,789,632								
gal/d	—	1,058,400	—	1,198,643								
Mscf/d	46,156	—	39,885	—								
C_4 (+) loss, gal/d	—	—	2,518	—								
L. O. vapor loss, gal/d	—	—	59	—								
L. O. circ. gal/Mscf	—	22.93	—	—								
Absorbed HC heavier than key component					2,412							
Absorbed HC lighter than key component					11,286							

TABLE 7. Absorption Oil Vaporization Loss in Absorber Residue Stream Estimation.

Calculation Steps	1	2	3	4	5	6	7	8
	Absorption oil to top tray mole fraction	Top tray equilibrium ratio K@530 psia, 85 F	Absorber residue stream mol/d	Absorption oil to top tray mol/d	Rich oil from top tray mol/d	Vaporized absorption oil in residue mol/d	Conversion factor gal/mol	Vaporized absorption oil in residue gal/d
TEST 1.								
Cut 400 F.....	0.0676	0.000220	—	—	—	1.20	24.49	29
Cut 450 F.....	0.5514	0.000051	—	—	—	2.24	27.00	60
Cut 500 F.....	0.3132	0.000016	—	—	—	0.40	29.93	12
Cut 550 F.....	0.0498	0.000005	—	—	—	0.02	33.15	1
Total.....			108,589	20,995	28,529			102
	mole faction	K@520 psia 80 F	mol/d	mol/d	mol/d	mol/d	gal/mol	gal/d
TEST 2.								
Cut 400 F.....	0.0462	0.000200	—	—	—	0.74	24.09	18
Cut 450 F.....	0.2077	0.000045	—	—	—	0.75	26.77	20
Cut 500 F.....	0.5806	0.000014	—	—	—	0.67	29.69	20
Cut 550 F.....	0.1179	0.000004	—	—	—	0.04	33.02	1
Total.....			104,960	37,412	48,698			59

However, a comparison of Tables 5 and 5A definitely proves that when the value of this correction term is rather large, the results of absorber performance evaluation fall far apart.

Table 5A shows that when absorption oil is assumed to be completely stripped, the absorber tray efficiency value with propane as key component is calculated to be only 15 percent. Also use of this incomplete evaluation will give an erroneous explanation for the poor performance of the primary absorber during Test 2. It would always be a good practice to check one's assumption by making an actual test.

ESTIMATION OF ABSORPTION OIL VAPORIZATION LOSS

In the operation of a primary gas absorber, vaporization loss of solvent in the residue gas stream is a processing cost item. In evaluating performance of an absorber, estimation of magnitude of this loss will be useful. Table 7 is presented to serve that purpose. The basic assumption for calculations of Table 7 is that the residue gas leaving the absorber top tray is in equilibrium with the liquid leaving the top tray. The quantity of liquid leaving the top tray is estimated by adding the amount of absorbed hydrocarbons lighter than the key component to the quantity of liquid to the top tray. The mole fraction of solvent in top tray rich oil is calculated by multiplying calculation steps 1 and 4 and dividing it by step 5. This solvent liquid mole fraction is then multiplied with its K-value and total moles of residue gas to give loss of solvent in the residue due to vaporization.

COST ESTIMATE OF PERFORMANCE TEST

Since a good engineer must be cost conscious, an estimate for making a performance test will be of great general use. Table 8 gives an estimate of cost of making a performance test by breaking it into three cost items.

- procurement of fluid samples and their operating data,
- getting component analyses,
- evaluation and interpretation of the test.

The cost figures of Table 8 are believed to be on the high side. The cost of evaluation and interpretation can vary a great deal and therefore, it is given as a range of minimum to maximum values. The benefit to be derived from evaluation may also vary in direct proportion to the ability and skill of the engineer making the evaluation.

TABLE 8. Cost Estimation of Performance Test.

	Test 1		Test 2	
	Primary absorber	Entire plant	Primary absorber	Entire plant
Number of fluid samples tested.....	4	15	6	12
Cost estimate breakdown				
1. Procurement of test samples and operating data....	$100	$250	$100	$200
2. Getting component analysis.....	200	750	300	600
3. Evaluation and interpretation of test results.....	50 to 350	100 to 1000	50 to 350	100 to 1000
Total.....	$350 to 650	$1100 to 2000	$450 to 750	$900 to 1800
Estimated payout, days (based on $80 daily loss of butane (+))...	—	—	10	23

Oftentimes, after the gasoline plant is designed, constructed and put into operation, the quantity and quality of raw materials available for processing are quite different than those used in the original design basis. Finished products sale prices are also varying because of changes in the market situation. A carefully conducted and expertly evaluated performance test will certainly provide a tool for sorting out factors which contribute toward plant's products income and factors which contribute toward plant's processing costs. A prudent plant operator and owner will adjust these factors in such a manner that the plant will produce a maximum possible net profit. ★ ★ ★

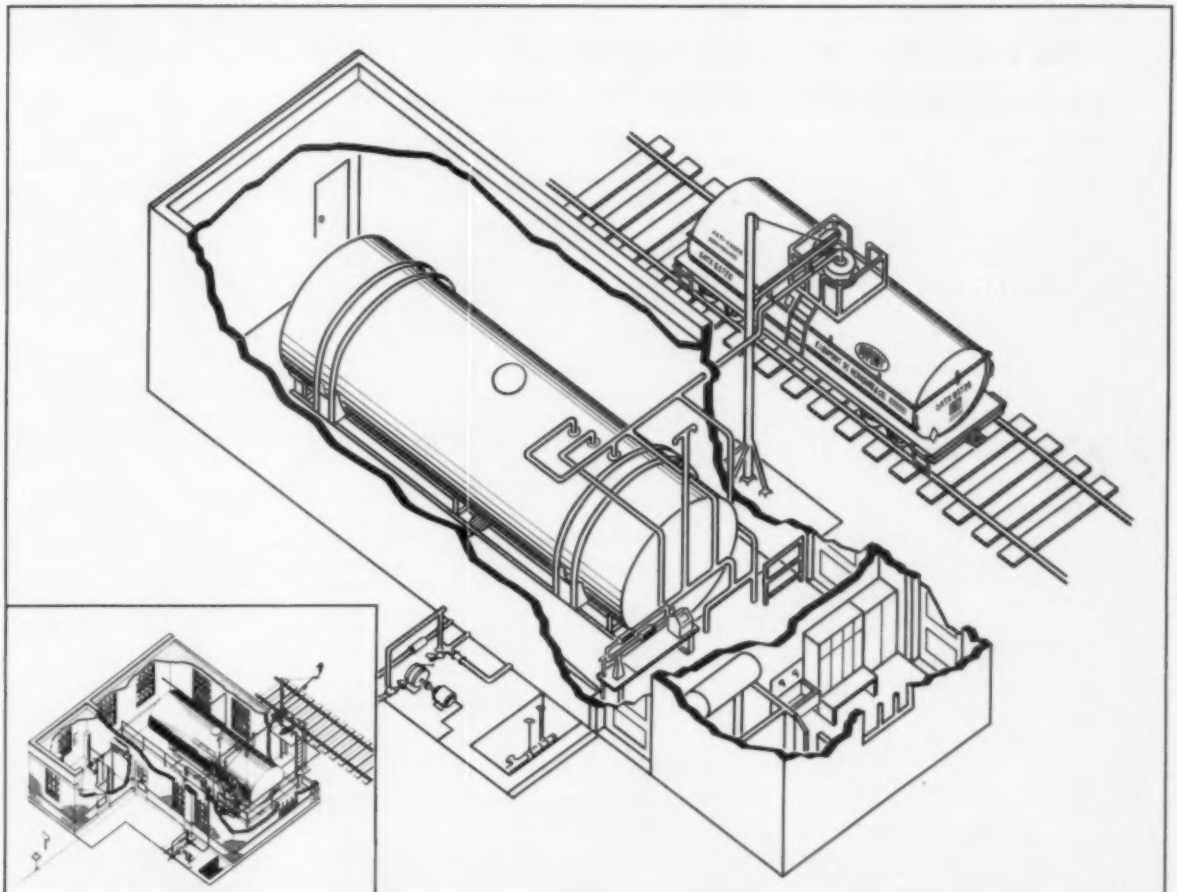
DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas.**

DU PONT *Petroleum Chemicals* NEWS

Number 102 in a Series of Bulletins for the Petroleum Industry

MAY-JUNE 1960

New TEL blending plant design puts more efficiency into less space



NEW TETRAETHYL LEAD BLENDING PLANT represents a major design change made possible by Du Pont's continuing efforts to develop new methods for more efficient use of petroleum additives by refiners.

Du Pont design reduces unloading time, cuts construction and maintenance costs

Ever since Du Pont designed the first tank-car-to-weigh-tank tetraethyl lead blending plant in 1928, our continuing research programs have yielded many refinements in blending plant equipment and operation. Among them have been the metal-flex unloading hose, the siphon starter and hydraulic system modifications.

Du Pont engineers have now figuratively taken apart and redesigned the TEL blending plant from the ground up. Their goal was to develop a design that incorporates new engineering developments and materials.

They tested valves, fittings and components to determine their actual interrelations. They evaluated the relationship of tank car and weigh tank. They investigated construction costs. They accumulated mountains of facts and details.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

Railroad learns what happens when it stops using FOA-2

Not long ago, a leading railroad tried an interesting experiment:

They had been using Du Pont FOA-2 to keep diesel locomotives free from filter plugging and other potential fuel problems. At one point, however, they felt that the sludge problem wasn't severe enough to justify continued use of the additive. So they discontinued use of FOA-2 in certain fuels, to measure its value.

Shortly after the test started several cases of fuel incompatibility were reported for the first time; filter plugging increased; and it was quickly found that the cost to replace the filters was more than the cost of the FOA-2 they had previously used.

Today, this railroad is once more using FOA-2 to reduce sludging and keep filters clear. Costs and maintenance and worries are once more back in line.

Du Pont AFA-1 provides economical corrosion protection for Aviation Fuels

Refiners are reminded of the very high effectiveness of Du Pont AFA-1 Aviation Fuel Additive as a corrosion inhibitor.

Concentrations as low as 2-4 pounds per 1,000 gallons have been found to produce rust inhibition in some fuels by the modified ASTM D665-54 Dynamic Rust Test.

Exact dosages, of course, depend upon the characteristics of the fuel itself. But the consistently low amounts of AFA-1 required can mean substantial savings in your additives costs. (Another advantage of AFA-1: the water tolerance test on aviation gasolines as jet fuels is more easily met.)

In addition to automotive and aviation gasolines, Du Pont AFA-1 brings the advantages of corrosion inhibition to other petroleum products such as heating oils and diesel fuels. Contact your Du Pont Petroleum Chemicals representative for additional information. Ask for our bulletin on Du Pont AFA-1.

CONTINUED *Plant redesign*

Mathematical Model

From these data, a mathematical model was built which could be modified at will and examined by computers. The Univac then translated these models into actual blending plant designs. For any prospective design, for example, Univac could evaluate such data as specific gravity of the fluid, viscosity, barometric pressure and initial vacuum to determine unloading time. Optimum performance values were then established.

The result: an updated lead blending plant design that:

Reduces unloading time because every valve and fitting is operating at its known, optimum capacity. The operator's effort is reduced as well, since his work area is now at the *end* of weigh tank. Waste motion is eliminated.

Reduces construction costs through a more compact, modern design. The "straight-line" plant occupies less floor area, eliminates windows and the former "L" floor plan. With the weigh tank installed on the scale, several tons of structural steel supports are eliminated.

Reduces maintenance, for example, through a new ball valve design which provides for low pressure drop. This valve is equipped to minimize leakage and packing problems.

Full Details Available

Interested refiners can obtain full details on this new blending plant design by contacting the nearest Du Pont Petroleum Chemicals representative. His office is listed in the box below.

You ought to know

LEWIS Z. CAREY, manager of our Pittsburgh district office. He succeeded the late Afton D. Puckett in mid-1959.

A native Philadelphian and a graduate of the University of Delaware, Lew Carey first came to Du Pont in 1941 when he joined the Organic Chemicals Department. Later that year he began four years of military service as gunnery officer aboard a destroyer escort.

He returned to Du Pont late in 1945 and was a sales correspondent for our Alcohol and Camphor Division until 1951, when he joined the operations section of the Petroleum Chemicals Division as a technical assistant. Shortly afterward he became a sales service representative in our Eastern region, and then became the first manager of our Philadelphia district office in 1955. In that assignment, he was effective in serving the petroleum refiners and marketers in that area with the technical, marketing and refining know-how of Du Pont's Petroleum Chemicals Division.

SALES OFFICES

Chicago 3—8 So. Michigan Ave. . . . RAndolph 6-8630
Cleveland 15—101 Prospect Ave. . . . . MAin 1-3422
Houston 2—705 Bank of Commerce Bldg. . . . . CApitol 5-1151
Los Angeles 17—612 So. Flower St. MAdison 4-1354
New York 20—45 Rockefeller Plaza . . . . . COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza LOcust 8-3531
Pittsburgh 22—1 Gateway Center . . ATlantic 1-2933
San Francisco 4—111 Sutter St. . . . . EXbrook 2-1934
Seattle 3—4003 Aurora Ave. . . . . MElrose 2-6977
Tulsa 1—1811 So. Baltimore Ave. . . . LUther 5-5578
In Canada—Du Pont of Canada Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12,** Ontario . . . . . HUdson 1-6461
OTHER COUNTRIES: Petroleum Chemicals Division, Export Sales, Wilmington 98, Delaware . . . . . PRospect 4-2962

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-14686

Printed in U.S.A.

DISTILLATION . . .

in View of Modern Developments

a series on recent developments in distillation and absorption techniques

Part II Distillation

Chapter 2c Theory of Fractionation — Minimum Work

Kenneth F. Gordon
University of Michigan
Ann Arbor, Michigan

James A. Davies
Texaco Inc.
New York City

IN DISTILLATION, heat costs are often a major portion of the total expense and it is of interest to determine the minimum amount of heat or energy required for a given separation in order to establish the lower limit which cannot be passed.

From thermodynamics it follows that the minimum energy required for the isothermal constant pressure separation of a mixture is given by the change in Gibbs Free Energy between the initial and final states. This is the thermodynamically reversible work. To establish the isothermal work or free energy required to separate a mixture, we may imagine that we isothermally compress the appropriate amount of each component separately, as a vapor in parallel, from its equilibrium partial pressure above the feed mixture to the pressure above each of the products, bottoms B and distillate D. For illustrative purposes we can call upon fictitious compressors with semi-permeable membranes as in Fig. 1. By allowing heat to flow in and out of the system, it can

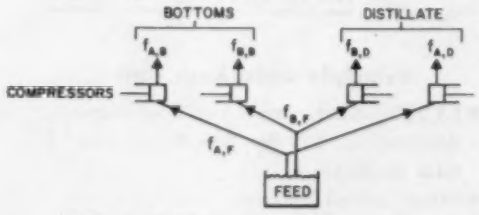


FIG. 1. Fictitious compressors in series.

be kept isothermal. By operating each fictitious compressor at the appropriate rate the liquid which remains is kept at a constant composition. This work is given by

$$-W = \Delta G = \Delta H - T\Delta S = RT\Sigma n_B \ln \frac{f_B}{f_F} + RT\Sigma n_D \ln \frac{f_D}{f_F} \quad . \quad . \quad . \quad . \quad (1)$$

with one term in the summations for each component. Pressures may be substituted for fugacities if the gases are ideal. To make this minimum as small as possible the temperature used in the equation would be the lowest available, that of the heat sink. By compressing slowly enough the system will be isothermal.

For a component to go from the liquid phase to the vapor phase at its partial pressure existing above the liquid, requires no net work, just the enthalpy of evaporation which can be supplied by the surroundings with heat flowing in at the temperature of the surroundings. Likewise, no useful work is available when the vapor at its saturated condition condenses to the saturated liquid phase. (Although there is work done either by or against the atmosphere, $P\Delta V$, this is not shaft or useful work. If it were desired to include this then we could use the Helmholtz Free Energy, $\Delta A = \Delta E - T\Delta S$, but this is of no concern in this discussion.) From the above or from the defining equation of the Gibbs Free Energy, $\Delta G = \Delta H - T\Delta S$, it is seen that the change in free energy for evaporation or condensation is zero and Equation 1 gives the change in Gibbs Free Energy of the processed material for the whole distillation process.

A distillation column may be regarded as a thermal engine for a separation process. With this concept, the net available work taken by the process would be the difference between available work into the still at the bottom and the available work out at the condenser. This work would go to accomplish the separation and to all the inefficiencies or lost work.

The fractionation thermodynamic efficiency is simply the ratio of the minimum work required to that actually employed in the sense that it is made unavailable. It can be regarded as the ratio of the increase in free energy (or availability of work) of the distilled material to the decrease in availability of work of the non-system or remainder of the universe. The thermodynamic efficiency is $\frac{\Delta G_{syst}}{-\Delta W_{av}}$. The work made unavailable may be regarded as consisting of two parts, that fraction of the work from pumps and compressors made unavailable and the change in thermodynamic availability of the reboiler heat as shown in Fig. 2. The work going in via pumps and compressors, $-W_s$, is totally available. The negative sign is used to follow thermodynamic convention so that work in is negative and $-W_s$ is itself positive.

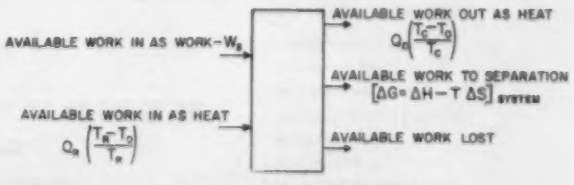

AVAILABLE WORK OUT AS HEAT
AVAILABLE WORK IN AS WORK $-W_s$
AVAILABLE WORK TO SEPARATION
$[\Delta G = \Delta H - T\Delta S]_{SYSTEM}$
AVAILABLE WORK IN AS HEAT
AVAILABLE WORK LOST

FIG. 2. Available work flowsheet.

STEAM GENERATORS

at SUNTIDE REFINING COMPANY

Viola, Texas

Above: Cross Section showing arrangement of steam and water drums, tubes, baffles, and furnace.

5 EFFICIENT AND ECONOMICAL UNITS SERVE THIS MODERN REFINERY

Principle Data Each Unit

- 85,000 pounds steam per hour capacity, designed for 500 lbs. S.W.P. and 625° F. total temperature.
- Water cooled furnace.
- Burners for Gas and Oil fuel.

Vogt offers a complete line of custom built and package type steam generators. Available in bent tube and straight tube designs for solid, liquid, or gaseous fuels burned singly or in combination.

Write for bulletins. Dept. 24A-BRE

OTHER VOGT PRODUCTS

Forged Steel Valves, Fittings and Flanges—
Petroleum Refinery and Chemical Plant Equipment
Heat Exchangers
Ice Making and Refrigerating Equipment

HENRY VOGT MACHINE CO.

Box 1918, Louisville 1, Kentucky

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J. St. Louis, Charleston, W. Va., Cincinnati, Los Angeles.

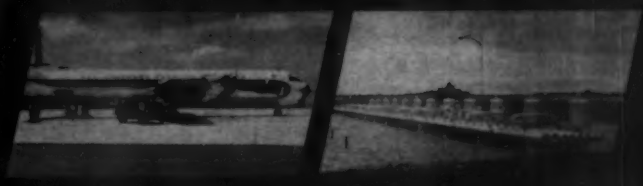
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

WARNER LEWIS COMPANY
BOX 1056 • TULSA OKLAHOMA

SILENT SERVANT OF SAFETY

jets

DEMAND CLEAN FUEL



Clean jet fuel is essential to safe jet aircraft operation. Today, all aviation fuels may be provided the ultimate protection against fuel contamination. The new Warner Lewis 2 stage separator filter eliminates jet fuel contaminants — free water and dirt — and delivers the cleanest fuel ever demanded by commercial or military aircraft.

A Silent Servant of Safety, this equipment is installed on fueling facilities serving most of the world's major airports. It is approved and in production for the U. S. Air Force under recent contracts. For further information, write Aviation Products division, Warner Lewis Company.

DIVISION OF FRAM CORPORATION In Canada — Canada Ltd., Stratford, Ontario

Nomenclature

A	Helmholtz Free Energy
f	fugacity
G	Gibbs Free Energy
H	Enthalpy
n	Moles of a given component
L	Liquid flowrate
P	Pressure
Q	Heat
R	Gas constant
S	Entropy
T	Absolute temperature
V	Volume or vapor flowrate
W	Work
Σ	Summation

Subscripts

av	Available
A, B	Components
C	Condensation
B	Bottom product
D	Distillate
F	Feed
o	sink
R	Reboiler
s	shaft or useful

By means of a Carnot cycle, the heat going to the reboiler, Q_R, may be made to yield work of amount $\frac{Q_R (T_R - T_o)}{T_R}$ where T_o is the temperature of the heat sink. Likewise, the work available from the heat going out in the condenser is $\frac{Q_C (T_C - T_o)}{T_C}$ where T_C is the temperature of condensation; then

$$-\Delta W_{av} = -W_s + Q_R \frac{(T_R - T_o)}{T_R} - Q_C \frac{(T_C - T_o)}{T_C}$$

$$= -W_s + Q_R - Q_C - T_o \left(\frac{Q_R}{T_R} - \frac{Q_C}{T_C}\right)$$

$$= -[\Delta H - T_o \Delta S]_{\text{non-system}}$$

where ΔH = change of enthalpy of the non-system

$-Q_C$ = heat out of the system via the condenser

Q_R = heat into the system via the reboiler

$-W_{av}$ = decrease in availability of work in the non-system

$-W_s$ = work into the system

As velocity and elevation effects may be neglected ΔH is also equal to the negative of the change of enthalpy for the material distilled. When feed and products are either all saturated vapors or all saturated liquids ΔH is usually very small. The increase of entropy, ΔS, is that of the non-system which in general is markedly different in value than the decrease in entropy of the system. The inefficiency arises because the increase of entropy of the non-system is greater than the decrease in entropy of the system resulting in a net increase in the entropy of the universe.

Another definition of efficiency is the ratio of the increase of entropy in a thermodynamically ideal system to the minimum entropy increase in an ordinary distillation. Using this definition, a maximum efficiency occurring at minimum reflux has been calculated [1] as 69.3 percent for the complete separation of close boiling components as an ideal solution of 0.5 mol fraction of each component. This maximum will be higher for solutions with positive deviations from ideality, like enthanol-water and less for those with negative deviations. The efficiency approaches zero as the feed concentration becomes that of either pure component. Such calculations are available.[1,3] Very little concerning this topic can be found in the current literature. A Swiss article [2] on thermodynamic work efficiency in distillation may be consulted.

Theoretically, the thermodynamic efficiency could be increased by having the stream entering each stage closer to the composition and temperature existing on the stage. This would require the operating and equilibrium lines to be closer together, which could be achieved by continuously varying the slope of the McCabe-Thiele operating line, L/V, by adding heat between each plate in the stripping section and removing heat between each plate in the rectifying section. Instead of all the heat being supplied at the high temperature of the reboiler, it would be supplied at decreasing temperatures up the column to the feed plate. Likewise, some of the heat of condensation would be available at temperatures higher than the condenser. In this manner, it is theoretically possible to achieve 100 percent thermodynamic efficiency for the complete separation of a binary system in ordinary distillation. However, in azeotropic and extractive distillation, as well as multi-component distillation, generally it would not be possible to add the feed in thermodynamic equilibrium with the feed plate composition, and these systems are sometimes called partially reversible in contrast to the ordinary binary distillation system which is known as potentially reversible.

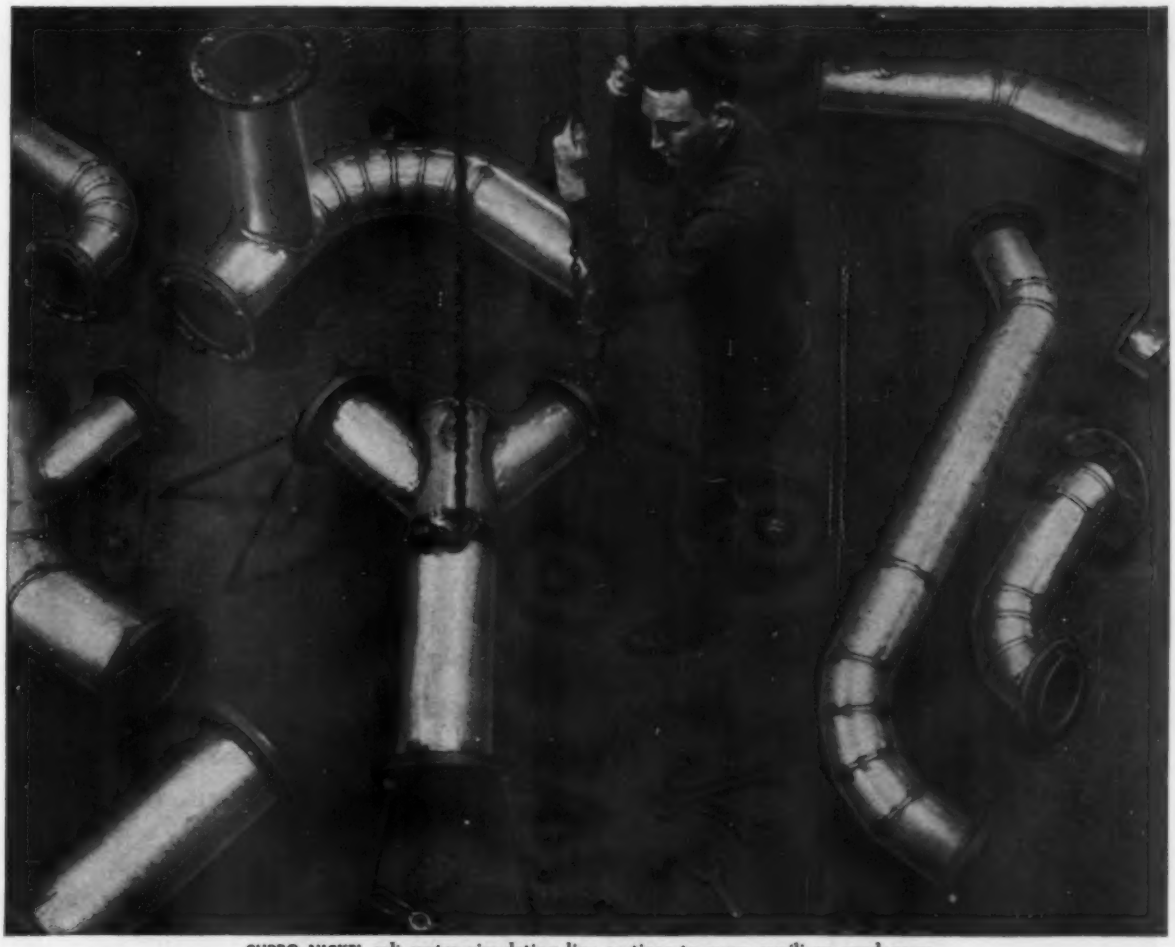
To increase the thermodynamic efficiency various designs are possible. The feed may be preheated by using it as the cooling fluid in the first condenser of two in series at the top of the column, with cooling water being used in the second. Vapor recompression has been used to a limited degree. Here the vapor from the top of the column is compressed to a higher pressure, sent into the heating coils of the reboiler where it condenses, giving off heat to the vaporizing liquid. This condensate is split to liquid reflux and distillate product. Various designs are possible where the vapor from the first tower provides heat by condensation in the coils of the second of two towers, which is at a lower pressure. Here no bulky compressor is required, but a liquid pump is necessary if the condensate in the second tower reboiler is returned to the first as reflux. This is not necessary if the first tower is a charge stripper. While multi-effect evaporators are well known for the separation of a salt from water, the corresponding principle is not extensively applied in distillation. One well known separation employing the split tower system is that of the distillation of liquid air as given in a previous chapter.

While the above concepts do not have extensive application, they are very useful in defining the achievable limits of progress in saving heat and are valuable in the examination of severe cases.

References

1. Benedict, M., Chem. Eng. Prog. (*Trans.* AIChE., Sect.) *43*, 41 (1947).
2. Kuhn, W., A. Narten, and E. Peterli, *Helv. Chim. Acta*, *40*, 1066 (1957).
3. Robinson, C. S. and E. R. Gilliland, *Elements of Fractional Distillation*, McGraw-Hill, New York, 1950.

★ ★ ★



CUPRO NICKEL salt water circulating line sections to serve auxiliary condensers aboard gypsum rock carriers recently fabricated by Boro Marine & Industrial Corp.

Wide variety of Cupro Nickel piping for salt water lines is readily made from sheet by welding

Circumferential joints are welded manually. Longitudinal seams are welded in mechanized equipment by inert-gas, metal-arc processes.

Ever higher velocities in salt water lines and the growing economic importance of continuity in service, on shipboard, and also in tidewater power plants and oil refineries, are leading to increasing use of Cupro Nickel in piping.

Techniques and skills for economical fabrication of even the most complicated elements of Cupro Nickel piping systems are keeping pace. Boro Marine & Industrial Corp., Port Richmond, Staten Island, N. Y., a specialist in the field, forms piping in sizes 6" to 24" diameter from Anaconda Cupro Nickel stock sheet, usually 48" x 96" x 3/16". Elements shown above indicate the variety possible. Seamless tubing is used for smaller diameters.

Boro Marine fabricates piping from both Cupro Nickel 30%-702 and Cupro Nickel 10%-755. The trend, however, is to Cupro Nickel 10%-755 for the majority of salt water line installations on commercial vessels and in industrial jobs, according to M. E. Wuensch, president. The alloy was developed by Anaconda for this kind of service. It is resistant to corrosion by both clean and polluted sea water, even at relatively high velocity of flow, and is resistant to corrosion by sea water containing air bubbles.

TECHNICAL ASSISTANCE. For help in selecting the alloy best suited for a particular job in heat transfer and piping systems, call in your American Brass representative, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA®

CUPRO NICKEL MILL PRODUCTS

Made by The American Brass Company

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

hē′li-ŭm

When you consider Helium-Recovery you will automatically think of Stearns-Roger.

Most of the operating helium plants in the free world have been built by Stearns-Roger. In this one organization is collected the cryogenic knowledge, experience and practical background to engineer and construct economical and satisfactory helium plants.

Stearns-Roger can provide you with reliable designs, investment studies and overall assistance in helium, hydrogen, natural gas and rare gas problems.

Direct inquiries to

Stearns-Roger

THE STEARNS-ROGER MFG. CO. • DENVER, COLORADO

- DENVER
- HOUSTON
- EL PASO
- SALT LAKE CITY
- CALGARY

P.O. BOX 5370 • DENVER 17, COLORADO

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

for superior jet fuels...

MOLEX

TRADEMARK

THE PROCESS THAT PRODUCES A NEW KIND OF JET FUEL OFFERING BIG AND EXCITING POSSIBILITIES

Jet flight is here to stay. But jet *fuels*, like yesterday's gasolines, will be replaced by better, more improved types . . . the kind made possible by Molex.

A unique, new *continuous* process developed by UOP, Molex removes up to 99% of the normal paraffins in gasoline mixtures, produces a superior jet fuel with these exclusive advantages:

Higher heating value per pound
. . . for greater range or payload.

Lower luminosity
. . . for lower metal temperatures, less carbon deposit, lower overhaul expense.

Less smoke in engine exhaust
. . . for more effective smog control.

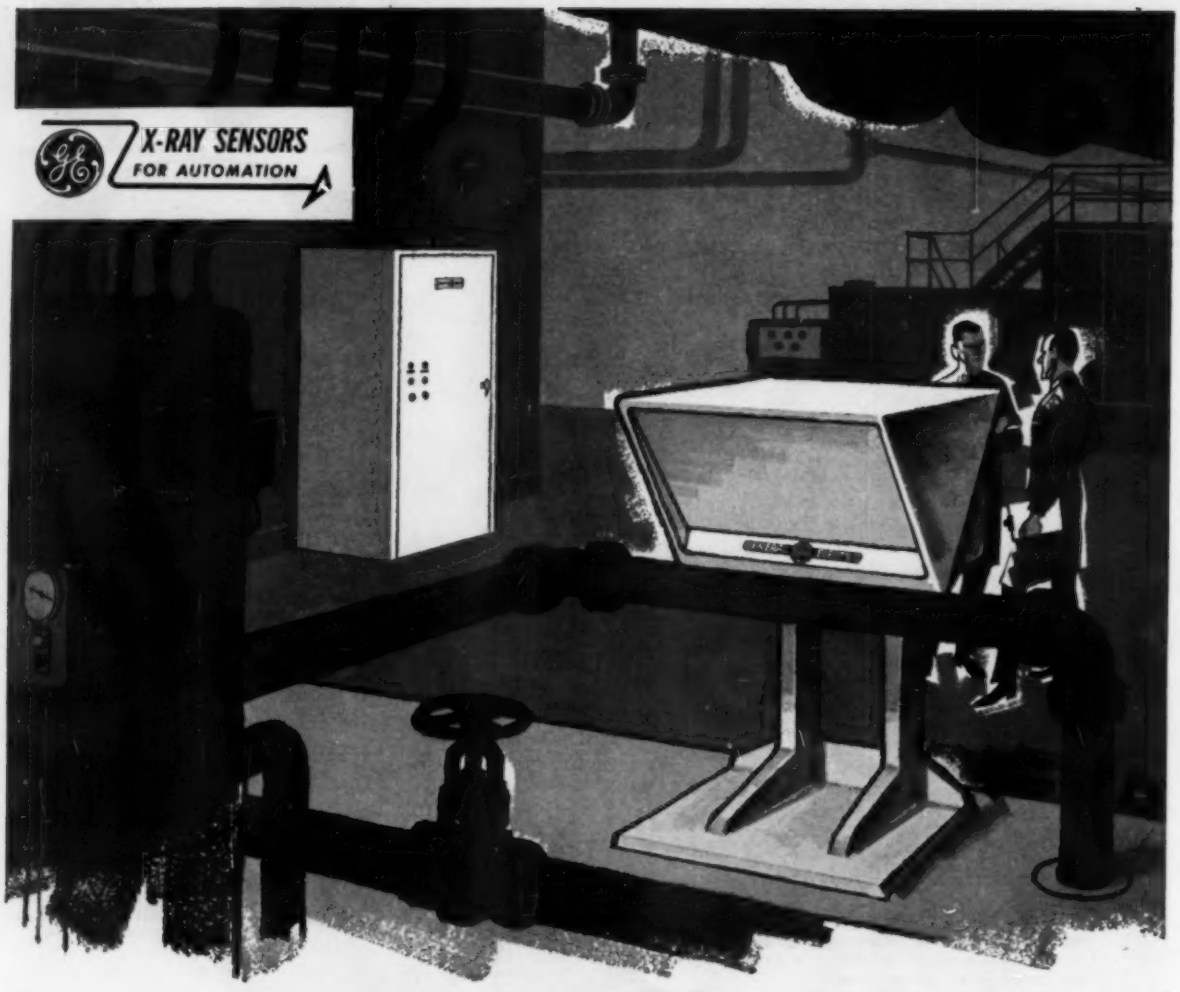
High thermal stability
. . . eliminates heat exchanger fouling.

'62 COULD BE THE YEAR FOR YOU!
The consensus of informed opinion is that 1962 will require a substantial increase in process capacity . . . NOW is the time to start your planning! Ask us about a preliminary proposal, no obligation!

UOP® UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road
Des Plaines, Illinois, U.S.A.

WHERE RESEARCH TODAY
MEANS PROGRESS TOMORROW



NOW...full-time analysis of materials in actual production

XEG X-Ray Emission Gage watches and measures up to 5 selected elements

Liquids or liquid mixtures, including solids — General Electric XEG X-Ray Emission Gage examines them as they actually flow through your pipelines during production . . . writes a running record of their elemental make-up. XEG tirelessly surveys up to five elements simultaneously, continuously . . . senses both their *presence* and *quantity*. Where practical to operate minus reference, even analyzes sixth element.

Versatile XEG serves equally well for on-line process control or individual-sample analysis. Scientifically trained operator is not required — because once set for specific analysis, there's little need for further adjustment. XEG then automatically delivers the facts on composition for rapid-fire, continuous feedback to process control.

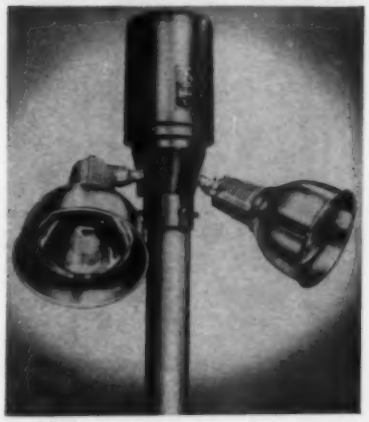
Applications are as limitless as your imagination. And, whenever you like, we can explore XEG potentials with you. The details are available now from your G-E x-ray representative. Or write us at General Electric Company, X-Ray Department, Milwaukee 1, Wisconsin, for Pub. RE-54.

Progress Is Our Most Important Product

GENERAL ELECTRIC

New Equipment

Mercury Vapor Floodlight



Full-floating socket construction that adjusts automatically to variations in lamp sizes and shapes is featured in a new mercury vapor floodlight. This assures perfect weather-seal with all makes of R-60 reflector lamps, 400-watt mercury vapor as well as 750-1000-watt incandescent. *Stonco Electric Products Co.*

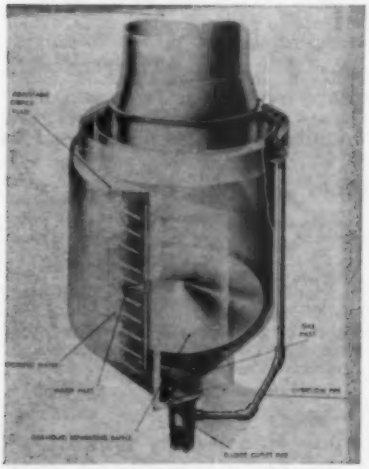
Circle number (41) on reply card.

Polyethylene Plugs

New polyethylene-coated plug for use with saran-lined plug valves is now available from The Saran Lined Pipe Company of Ferndale, Michigan. New plug is designed to eliminate "freezing" that sometimes occurs when lubrication fails. *The Dow Chemical Company.*

Circle number (42) on reply card.

High Energy Scrubber



Adjustable orifice scrubber, available in wide range of capabilities, controls acid mists, tar fog, petroleum coke dust, fumes from metallurgical operations, catalyst dusts, and other fine particles. Performs both agglomeration and separation in one compact unit. *The Ducon Company, Inc.*

Circle number (43) on reply card.

Control Valves

New 20000 series of single seated control valves, engineered to meet requirements of modern process and power plant applications, features high capacity, ability to handle high pressures and pressure drops, and a wide selection of reduced capacity trim. *Mason-Neilan, Division of Worthington Corp.*

Circle number (44) on reply card

Adjusting Rods

All OPW-Jordan diaphragm control and temperature control valves are now equipped with adjusting rods, securely chained to the valves. This makes it more convenient to adjust the spring tension. *OPW-Jordan Corporation.*

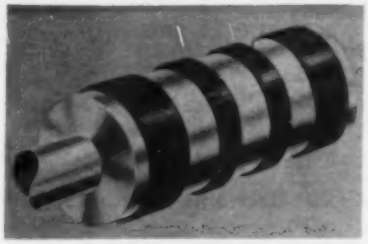
Circle number (45) on reply card.

Seamless Welding Fittings

Midwest has added seamless carbon steel welding fittings to their line of welded-type fittings. They are available in sizes ranging through 24 in. *Midwest Piping Company, Inc.*

Circle number (46) on reply card.

Teflon Piston Rings



Filled Teflon piston rings, now on market, are ideal for non-lubricated service to seal reciprocating, oscillating and rotary motion of both external and internal cylindrical surfaces against leakage of liquids or gases. Matched filled Teflon rider rings are also available for use with rings where long stroke or heavy pistons necessitate additional support. *The Garlock Packing Company.*

Circle number (47) on reply card.

Automatic Degausser

Type 5-055A automatic tape degausser can be used with tapes from ¼ to 2 in. in width, reels from 7 to 14 in. in diameter, and reel hubs of all dimensions. A reel of instrumentation tape recorded to saturation is erased to at least 50 db below normal record level. *DataTape Division of Consolidated Electrodynamics Corp.*

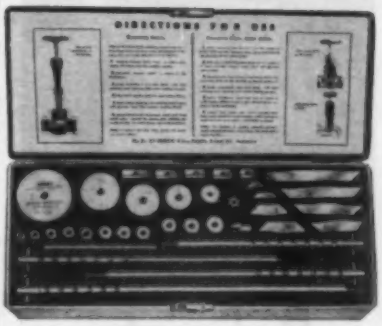
Circle number (48) on reply card.

Semiconductor Networks

Solid circuit semiconductor networks are now commercially available, three years ahead of industry predictions. TI Type 502 is a binary multivibrator capable of operation at a 200 kc repetition rate with 6-volt power supply. Unit can be interconnected for use as a shift register, binary counter, or set-reset flip-flop. *Texas Instruments Incorporated.*

Circle number (49) on reply card.

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

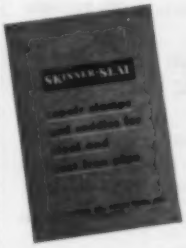
Reseats flat and tapered-seat globe or angle valves—all bibbs and faucets—In place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

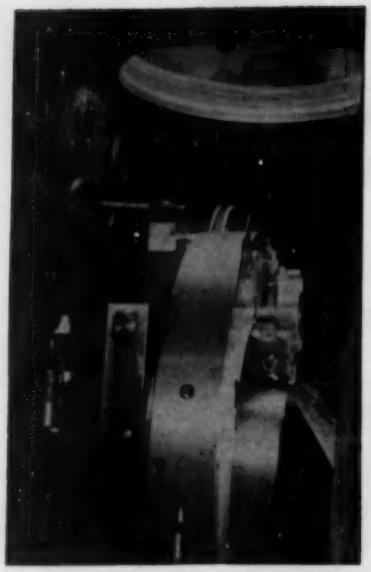
2" for ¼" to 2" valves and ¼" to ¾" bibbs
List price $59.85

3" for ¼" to 3" valves and ¼" to ¾" bibbs
List price $79.50



FREE catalog showing our pipe repair clamps, saddles, and reseating tools

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA



...Refinish Crank-Pins ...In Place!

- Accurate High Quality Maintenance And Machine Work

The small engine crank pictured above was restored in close quarters without dismantling engine. Our portable machines can solve your problems and save you money. Crank pins from 5½" through 20" in diameter accurately refinished in place at great saving in cost. **Let us help you minimize down time.**

Worn and damaged flywheel fits refinished in place.

In our shop crankshafts of any size or type completely refinished. Shafts straightened and broken shafts successfully repaired.

Most modern methods used in rebabbitting and machining engine and turbine bearings.

All types of heavy power plant equipment serviced with special attention given to emergency repairs.

Additional information furnished without obligation.

WASHINGTON IRON WORKS, INC.
Established 1876
SHERMAN, TEXAS
Pho. TW—2-8145

Multipoint Recorder

Honeywell Universal Model 15 Electronik Recorder is a multipoint strip chart recorder which can easily be converted to change the number of points being measured, the actuation, or the range. Measurements can be switched from 2 to 3, 4, 6, 8, 10, 12, 16, 20, or 24 points by changing indicating and print wheels and shorting plug. Substitution of new range card, terminal panel, and scale changes actuation and range. *Minneapolis-Honeywell Regulator Co.*

Circle number (50) on reply card.

Epoxy Resin Coating

Scotchkote pipe protection resin No. 101, an epoxy resin coating for pipe corrosion protection, can be readily applied to irregular shapes, such as pipe fittings. It applies evenly to all surfaces, providing a finish with high electrical and mechanical strength. It cures in less than 20 sec, with close coating tolerances. *Minnesota Mining and Manufacturing Co.*

Circle number (51) on reply card.

Television Camera

World's most rugged television camera is built to withstand weather, shock, vibration, noise, salt spray, dust, and other extremes of environment without an auxiliary protective housing. Designated the Dage Model RGS-10 Ruggedized Television System, it consists of a camera and camera control capable of being operated up to 2000 feet apart. Engineered to military requirements for missile and aircraft programs, system is applicable in such industries as chemical plants and oil refineries. *Dage Television Division, Thompson Ramo Wooldridge Inc.*

Circle number (52) on reply card.

G-20 Electronic Computer

New large-scale transistorized G-20 electronic data processing system, capable of 45,000 floating point operations per second, is rated 100 times as fast as conventional computers in same price class. The equipment is comparatively inexpensive, and operating costs also are quite low because it is all solid-state and highly automatic. *Bendix Computer Division, Bendix Aviation Corporation.*

Circle number (53) on reply card.

Test Heaters

Two portable high-temperature experimental test heaters have been developed to evaluate proposed applications of the Ljungstrom air preheater to new processes. They are being used to determine what the performance of the preheater would be when applied to fuel burning equipment where the characteristics of flue gases are unknown. *The Air Preheater Corporation.*

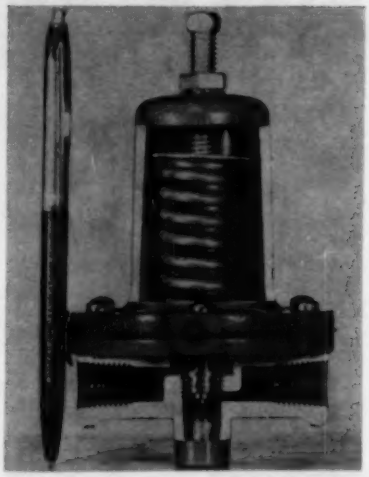
Circle number (54) on reply card.

Coupling Gasket

New grooved type coupling gasket, the Style "E" End Protection Gasket, protects bare ends of cement or plastic lined pipe at joints. Using the Style "E" Gasket with the company's standard Rigi-Grip coupling puts an end to "crevice corrosion" common in welded and threaded pipe joints where fluid flow is interrupted. *Gustin-Bacon Manufacturing Company.*

Circle number (55) on reply card.

Instrument Regulator



The "080" Instrument Regulator, applicable wherever a controlled supply of air or gas pressure is needed, can serve as first stage regulator for LPG systems. Has maximum inlet pressure of 250 psi and outlet pressure ranges of 0-5, 5-35, and 35-100 psi. Optional construction includes handwheel adjustment and ¼-in. side outlet tap for pressure gage mounting. *Rockwell Manufacturing Company.*

Circle number (56) on reply card.

Teflon-Lined Hose

Flexlon hose withstands all known chemicals except fluorine gas, chlorine trifluoride, and molten alkali metals. Teflon tube is bonded to the hose body, which eliminates separation, cracking, or splitting, even with small bending radii. *Manhattan Rubber Division, Raybestos-Manhattan, Inc.*

Circle number (57) on reply card.

Combustion Chemical

Nalco 159 is a clear, oil-soluble liquid designed to protect residual oil-fired boilers against slag and "cold-end" corrosion. Available in 54-gal, non-returnable steel drums, it can be added to the oil storage tank or pumped into oil transfer lines. *Nalco Chemical Company.*

Circle number (58) on reply card.

Fluid Cracking Catalysts

Two new fluid cracking catalyst compositions, Aerocat 3C-12 and Aerocat 3C-20, have been developed jointly by American Cyanamid Company and Shell Development Company. Pilot plant yield studies indicate that these new catalysts will enable refiners to realize higher profits from their catalytic cracking operations. *American Cyanamid Company.*

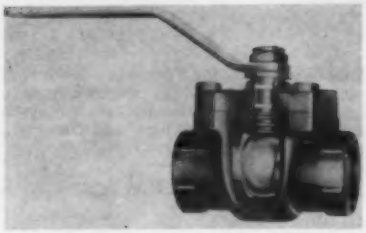
Circle number (59) on reply card.

Alloy Heavy-Duty Pumps

New line of heavy-duty type pumps made of stainless steel, monel, mild steel, and other alloys can be operated at up to 100 percent rated speed on thin liquids. Equipment costs are sharply reduced on certain models, since smaller pumps can now do the work of previously larger models. *Viking Pump Company.*

Circle number (60) on reply card.

Ball Valves



Two new ball valves, the McCannaseal (illustrated) and McCannaflo, both provide the full flow of a gate valve, the tight shut-off of a globe or needle valve, and the quick quarter turn of the plug valve. New designs permit them to take temperatures up to 350 F and pressures up to 700 psi for the McCannaseal and up to 1000 psi for the McCannaflo. *Hills-McCanna Company.*

Circle number (61) on reply card.

Bellows Flowmeter

Newly introduced bellows flowmeter can be used for both flow and liquid level applications. It is accurate within ½ of 1 percent using no mercury, seal-pots, purges, or stuffing boxes. Has ranges from 0-20 to 0-300 inches of water and may be changed by a simple exchange of the range spring assemblies. *Fischer & Porter Co.*

Circle number (62) on reply card.

New Marketing System

Smithway Marketing System for bulk petroleum products such as gasoline uses a decoding device in the office on an oil company dispatcher. Filling station operator's order for a bulk product is placed on a business machine card. Decoding device "scans" the order and gives dispatcher a code number which is phoned to the station operator. Operator punches up this number on a control panel at the station, and this automatically releases the amount of product ordered. *Smith-Erie Division, A. O. Smith Corporation.*

Circle number (63) on reply card.

Gas Engine

Model TPV, a 2-cycle, V-type, turbocharged gas engine is designed as a compact, high horsepower driver for centrifugal pipeline compressors, generators, and liquid pumps. Models are built with 10, 12, and 16 power cylinders, rated at 4000, 4800, and 6400 bhp respectively. *Clark Bros. Co., one of the Dresser Industries.*

Circle number (64) on reply card.

Bubble Detector

Ultrasonic bubble detector can be used to detect undesirable or uncontrolled bubbling in almost any liquid, in open or closed vessels, pipes, or flumes. Can be coupled with any type of indicating, recording, or controlling instrumentation, or simply with some type of alarm. *Taylor Instrument Companies.*

Circle number (65) on reply card.

RO-VAR Plenty Pumps

Eighteen sizes are available in these variable capacity positive displacement pumps. They range in capacities from 0 to 1 gal per min to 0 to 3000 gal per min, with discharge pressures up to 450 psi in single stage. Design is particularly well suited for pumping high viscosity materials such as reduced crude, oxidized asphalt, and residuals, as well as polymers, co-polymers, and resins. *Kearney Industries, Fluid Equipment Division.*

Circle number (66) on reply card.

New Literature

Petro/Chem Engineer . . . engineers in refining, natural gasoline, and petrochemicals processing may secure first issue of this new technical magazine. Petro/Chem Engineer is specialized for project engineers, process engineers, and design specialists. Technical service, operations, and maintenance engineers who work with design groups will also find Petro/Chem Engineer helpful. *Petroleum Engineer Publishing Company.*

Circle number (67) on reply card.

Advantages of Adjustable Damping . . . of flow pulsations in differential pressure transmitters are detailed in Bulletin 91-251. *Fischer & Porter Company.*

Circle number (68) on reply card.

Air-Operated Saunders Valves . . .are described in Bulletin HB-7, which gives construction details, operating characteristics and specifications. Included is a section on valve sizing and flow co-efficients which aid in proper selection of Saunders valves. *Conoflow Corporation.*

Circle number (69) on reply card.

Basic Guide . . . to ferrous metallurgy is now available in a 4-color 8½ by 11-in. version on 120-lb Krome-Kote. *Tempil Corporation.*

Circle number (70) on reply card.

Beckman Customers' Guide . . . explains company's various divisions, products, sales locations, and service facilities to assist the buyer in contacting the proper outlet for the products he needs. *Scientific and Process Instruments Division, Beckman Instruments, Inc.*

Circle number (71) on reply card.

Casting Selection . . . is explained in new booklet which offers comprehensive picture of all types of stainless steel and high-alloy heat and corrosion-resistant castings and their applications. *The International Nickel Company, Inc.*

Circle number (72) on reply card.

DURA FLEXIBLE STEEL CABLE SHAFT PACKING TOOLS

Save time and bother removing and installing packing by using these flexible shaft hand tools. They perform perfectly in those "hard-to-get-at" places.

Write for illustrated Bulletin No. 314-RE covering sets, sizes and prices

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Choosing an Antioxidant?

DALPAC® 4 SAVES YOU MORE

Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

For additional information write:

Oxychemicals Division
Naval Stores Department
HERCULES POWDER COMPANY
900 Market Street
Wilmington 99, Delaware

NOSS-58

Coal-Tar Coatings . . . formerly marketed under the name Barrett, are subject of booklet CAC-11-598. Primarily moisture barriers and impervious corrosion proofers, the coatings are particularly suitable for buried or immersed steel and concrete structures. *Allied Chemical Corporation, Plastics and Coal Chemicals Division.*

Circle number (73) on reply card.

Electrodes and Electrode Mountings . . . for industrial pH measurements are described in Data Sheet NS5(1). Two tables aid in selecting type of electrode and mounting needed for a wide variety of applications. *Leeds and Northrup Company.*

Circle number (74) on reply card.

Fiber Glass Reinforced Plastic Pipe . . . for chemical corrosion control is subject of Bulletin FRP-1. FRP armoring is applied to Haveg's established line of Phenolic and Furane pipe to give maximum in-plant safety. *Haveg Industries, Inc.*

Circle number (75) on reply card.

Fire-Retardant Paint . . . how it works and how it is applied in all types of industrial, commercial, and institutional buildings to improve personal safety and reduce potential fire damage is explained in Bulletin 100. *Albi Manufacturing Company, Inc.*

Circle number (76) on reply card.

Hardness Conversion . . . approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels is shown on Technical Data Card 183. *Tubular Products Division, The Babcock & Wilcox Company.*

Circle number (77) on reply card.

HI-DRY liquid desiccant . . . a special grade of tetraethylene glycol for use in removal of water from natural gas, is explained in new bulletin. Product, which provides additional dew point depression and superior thermal stability properties, can be used in conventional glycol absorption plants. *Jefferson Chemical Company, Inc.*

Circle number (78) on reply card.

Hodag Nonionics . . . new bulletin describes applications and tabulates properties of 37 representative nonionic surface active chemicals. Products are divided into four groups: glycerol esters, other polyhydric alcohol esters, polyglycol esters, and polyoxyethylene alkyl aryl ethers. *Hodag Chemical Corporation.*

Circle number (79) on reply card.

Instruments . . . for laboratory analysis, process control, and research are detailed in 16-page general catalog which describes techniques and instruments for leak detection, mass spectrometry, chromatography, moisture monitoring, and other types of analysis and control. *Consolidated Electrodynamics Corporation.*

Circle number (80) on reply card.

Multiport Relief Valves . . . for automatic, safe relief of overpressure in steam, air, and gas systems up to 250 psig are subject of Bulletin No. 5200-A. *Cochrane Corporation.*

Circle number (121) on reply card

Submersible Rotary Pumps . . . in storage tank service are described in folder which cites several typical installations and gives details of types, capacities, and construction of rotary pumps available. *Sier-Bath Gear & Pump Co., Inc.*

Circle number (122) on reply card

Sulfur Chlorides . . . new chemical safety data publication SD-77 gives safe handling procedures for sulfur monochloride and sulfur dichloride. 30 cents. *Manufacturing Chemists' Association.*

Circle number (123) on reply card

Super pressure tubing . . . capable of carrying internal pressures of 15,000 to 100,000 psi is described in Data Memorandum No. 22. Suggested applications include hydrogenation process equipment, high pressure autoclaves, and pilot plant installations in chemical and oil refining plants. *Superior Tube Company.*

Circle number (124) on reply card

Supports . . . for piping and equipment in the power, nuclear, refinery, marine, and chemical industries are dealt with in new 96-page book. Featured is system of pre-engineered piping and equipment supports utilizing standard component assemblies. *Bergen Pipesupport Corporation.*

Circle number (125) on reply card

for LEAKPROOF PRESSURE-TITE Connections . . .

TiteSeal®

SEALING COMPOUNDS

Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion and joint seizure.

7 BASIC BLENDS

LIQUID WRENCH

LOOSENS RUSTED BOLTS

A powerful blend of fast-acting solvents that literally "melt the rust away" —safe on all metals and alloys.

RADIATOR SPECIALTY CO.
CHARLOTTE, N. C.

Tank Preparation Wall Chart . . . is now available which has diagrams of seven factors to be considered in proper design and preparation of tanks to be lined to prevent corrosion or to eliminate product contamination. *Protective Coating Division, Metalweld, Inc.*

Circle number (126) on reply card

Testing apparatus . . . relating to soils, bituminous, concrete, and general testing, is subject of Digest No. 2. *TESTlab Corporation.*

Circle number (127) on reply card

Tubend welding fittings . . . stainless steel and aluminum fittings conforming to American Standard B16.9 are detailed in new 32-page catalog. *B.K.L. Alloys Ltd.*

Circle number (128) on reply card

V-1 Ballast Tray . . . a new valve type tray that utilizes 2-stage vapor discharge units with single moving elements is detailed in new technical bulletin 160. This new fractionating device has higher efficiency, greater flexibility, more usable capacity, and flood capacity equal to the company's original A-1 Ballast Tray. *Fritz W. Glitsch & Sons, Inc.*

Circle number (129) on reply card

Wolverine Trufin . . . integrally finned tube is described in new 4-page folder. *Wolverine Tube, Division of Calumet & Hecla, Inc.*

Circle number (130) on reply card

FACULTY BRIEFS

Prof. Wayne C. Edmister, member of the chemical engineering faculty at Oklahome State University, Stillwater, left April 30 for Holland, where he will spend a semester in advanced research at the University of Amsterdam's Van der Waals laboratory working with **Dr. A. M. J. F. Michels,** the discoverer of polyethylene plastics. Edmister will be studying under an International Research grant from the American Chemical Society's petroleum research fund.

W. C. Edmister

Prof. Robert W. Taft, Jr., Pennsylvania State University is 1960 recipient of the $1000 American Chemical Society Award in Petroleum Chemistry. The award is sponsored by the Precision Scientific Company of Chicago.

New Research Firm

Dr. Calvin N. Wolf has founded Princeton Chemical Research, Inc., a new contract research and development organization at Princeton, New Jersey, that will specialize in the fields of petrochemicals, polyolefins, and catalysis. Wolf formerly was manager of research for Petro-Tex Chemical Corporation at their Princeton laboratories.

WE HAVE DESIGNS ON EVERYBODY'S CHARGE STOCK

Serving processors who want high yields of high octane gasoline begins at Houdry, with three efficient and flexible catalytic processes.

The HOUDRIFLOW Process accepts in liquid or vapor form any fraction between naphtha and asphalt from both sweet and sour crudes. In the HOUDRESID Process, reduced crudes are converted into high octane gasoline and light distillate fuel—without production of heavy residual fuel.

Straight-run and cracked petroleum naphthas are converted to high octane gasoline, blending stocks, and aromatics by the efficient HOUDRIFORMING and ISO-PLUS HOUDRIFORMING Processes.

Complementing these processes, Houdry also offers catalysts, technical service, engineering, research, and economic consultation.

Write, outlining your interests or requirements, for a full description of specific ways Houdry may be able to serve you.

*HOUDRY

PROCESS CORPORATION
1528 Walnut Street, Philadelphia 2, Pa.
*Houdry means Progress...through Catalysis

PETRO/CHEM newsmakers

B. H. Johnson

A. T. Watson

F. W. Lampe

▸ Humble Oil & Refining Company's research and development division at Baytown, Texas announces the promotion of **Drs. B. H. Johnson, F. W. Lampe,** and **A. T. Watson** to research specialists.

▸ New staff members at the Richmond Laboratory of California Research Corporation include **Werner H. Schurter,** research engineer in the instrument development and maintenance group; **Hans L. Steinmetz,** research engineer in the process and plant design division, and **Barbara N. Bernstein,** research statistician in the process and plant design division.

▸ **E. K. Dewey, Jr.,** has been promoted to general maintenance engineer in Continental Oil Company's headquarters manufacturing department, Ponca City, Oklahoma. He previously was mechanical superintendent at Conoco's Lake Charles refinery. Dewey's successor at Lake Charles is **Roger M. Haynes,** who was mechanical superintendent at Billings, Montana.

▸ **Homer V. Flemming** has been named manager of the Houston office of The Ralph M. Parsons Company, engineers-constructors of Los Angeles. Flemming, formerly vice president in charge of sales for The Refinery Engineering Company, Tulsa, will be responsible for business development in the petroleum, chemical, and petrochemical industries throughout the Southwest region.

H. V. Flemming

F. G. Breyer

▸ **Fred C. Hands** has been appointed director of procurement for Goodrich-Gulf Chemicals, Inc., Cleveland. He formerly was plant manager of Goodrich-Gulf's synthetic rubber plant in Institute, West Virginia.

▸ In top-management organizational changes at Singmaster & Breyer, Inc., **Byron Marquis** was appointed president; **Frank G. Breyer** became chairman of the advisory committee, and **William H. Finkeldey** was moved up to chairman of the board. Marquis, Breyer, and Finkeldey formerly were vice president of engineering, chairman of the board, and president, respectively. Singmaster & Breyer, New York, is a process engineering firm for metallurgical, chemical, and nuclear industries, and an affiliate of The Fluor Corporation, Ltd.

W. H. Finkeldey

B. Marquis

Non-Burst

SUPER-MASTER

BW STEAM HOSE

- PRACTICALLY BURST-PROOF
- STATIC WIRE
- STEEL WIRE BRAID REINFORCED
- BUTYL COVER
- FOR PRESSURES TO 200 LB—(388° F)

WRITE FOR BULLETIN M630

Unusual strength and flexibility . . . maximum safety. Preferred by safety engineers for flash-fire protection, clean-up in refineries, steel mills, foundries . . . dock-to-ship steam supply lines. Made with Neoprene cover for refinery service. Master brand for 150 lb. pressure. Special Type for Pile drivers. Other engineered variations for special applications (higher pressures, temperatures, etc.) on request.

RM1038

RAYBESTOS-MANHATTAN, INC.

MANHATTAN RUBBER DIVISION, PASSAIC, NEW JERSEY

ENGINEERED RUBBER PRODUCTS . . MORE USE PER DOLLAR

RM

▸ **Bernard Berkeley** has been promoted to director of the product development department of Foster D. Snell, Inc., chemists and engineers, New York.

▸ New manager of the purchasing department of The Atlantic Refining Company is **F. N. Mann,** who since 1945 has served as director of the marketing personnel division. He succeeds **J. S. Parks,** who retired in March after nearly 45 years' service.

F. N. Mann

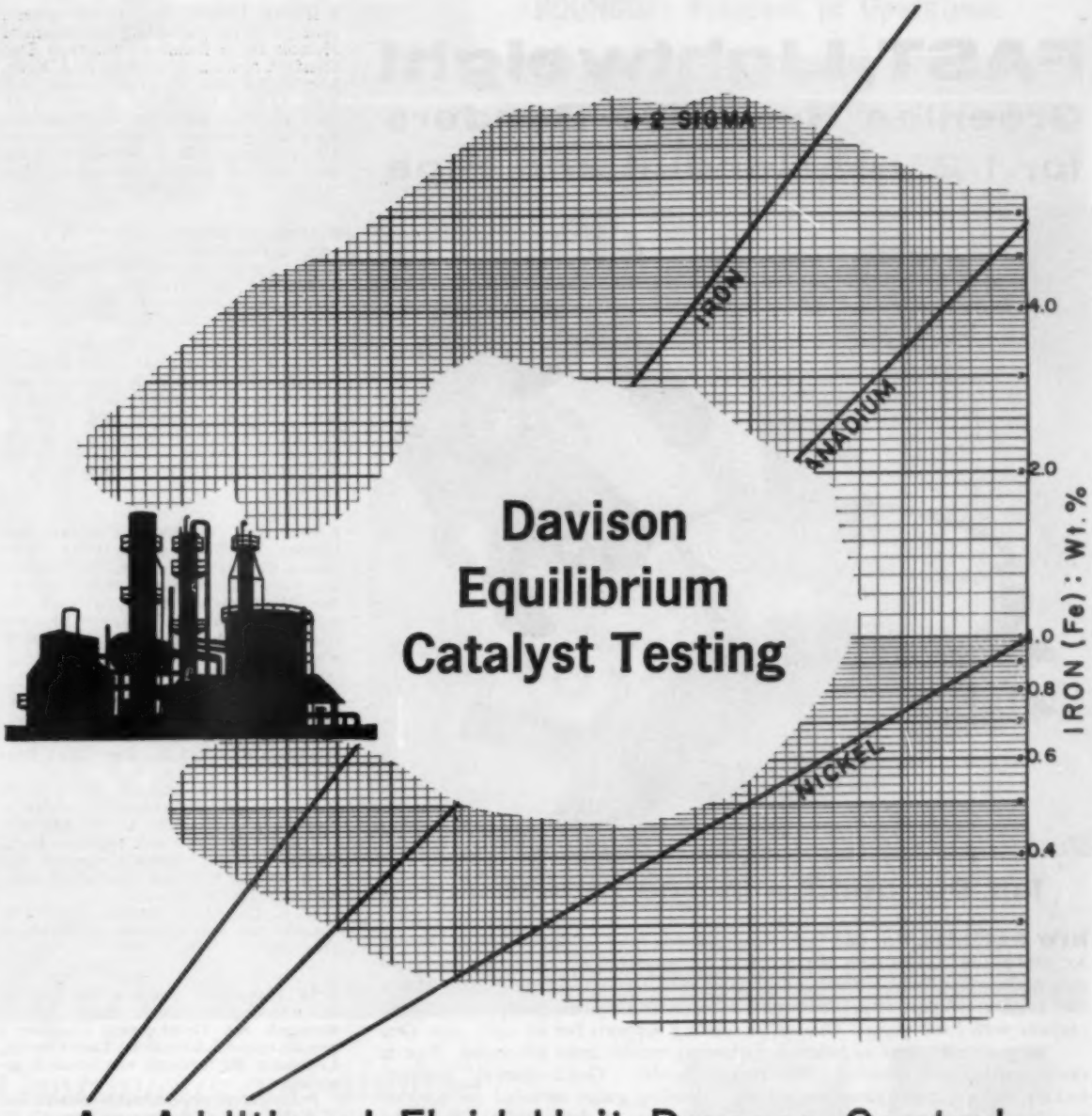
J. C. Reed

▸ Directors of Procon Incorporated, refinery and chemical construction company, announce the promotion of **James C. Reed** to executive vice president; **Alexander G. Petkus** to senior vice president, coordination, engineering, and drafting; **James R. Britt** to vice president, European operations, and **Charles B. Robbins** to vice president, staff. Formerly Reed was vice president in charge of construction; Petkus was chief coordinating engineer; Britt was general manager of Procon (Great Britain) Ltd., and Robbins was assistant to the president. Procon is a wholly owned subsidiary of Universal Oil Products Company.

A. G. Petkus

J. R. Britt

C. B. Robbins



Davison Equilibrium Catalyst Testing

An Additional Fluid Unit Process Control

Improve *conversion—selectivity—regeneration—fluidization* with the aid of this valuable Davison service. More than half of the fluid unit operators in North America rely on Davison Equilibrium Catalyst Testing. Find out how you can benefit. Ask your Davison representative or write Department B-05.

DEPARTMENT B-05

W.R. GRACE & CO.

DAVISON CHEMICAL DIVISION

BALTIMORE 3, MARYLAND

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

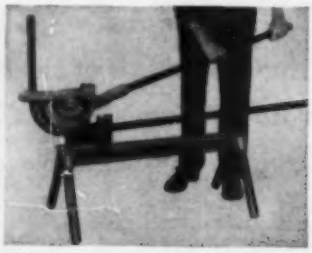
FAST, Lightweight
Greenlee Hydraulic Benders for 1/2"-4" Conduit and Pipe

full 90° bend with one ram stroke

NEW GREENLEE No. 883 Lightweight Hydraulic Pipe Bender quickly makes accurate bends in eight sizes of pipe from ½" through 3" . . . up to 90° with one ram stroke. Operates with either a portable power pump or hand pump. Makes 90° bend in 3" pipe in approximately 1 minute with power pump . . . only 10 minutes with hand pump. One set of rotating supports for all eight pipe sizes . . . supports also serve as rollers for wheeling bender from job to job. Pipe is easily inserted and removed from front of bender. "Quick-removal," positive-locking support pins cannot come loose. Bending gauge included for accurate results with minimum calculations. Get details now on the complete GREENLEE Lightweight Bender line that includes three models for ½" - 2" . . . ½" - 3" . . . and ½" - 4" pipe.

new, fast ratchet bender for ½", ¾", 1" pipe

GREENLEE No. 1800 Ratchet Hand Bender permits short, powerful strokes for easy, quick bending up to 90°. Swing-away clamp makes loading simple. Sturdy T-iron base sets anywhere or receives threaded pipe legs of any desired length. Built-in bending gauge reads 0 to 90°. See your distributor for a demonstration, or write for descriptive Bulletin E-291.



A COMPLETE LINE OF HYDRAULIC AND HAND BENDERS FOR PIPE AND TUBING

GREENLEE TOOL CO. GREENLEE

1757 Columbia Ave., Rockford, Illinois

› **Haylett O'Neill, Jr.,** is new general manager of the purchasing department of Humble Oil & Refining Company's Esso Standard division, succeeding **A. J. Kelly,** who retired after 41 years' service with Esso. O'Neill transferred to New York from Houston, where he was purchasing agent of the Humble division. His successor at Houston is **B. A. Warren,** who has been assistant general manager of Esso Standard's purchasing activities.

› **Alexander Bogrow,** director of European operations for Arthur D. Little, Inc., is in charge of the company's new Zurich, Switzerland, representative office recently opened to facilitate work with clients in Europe, North Africa, and the Near East.

› **Harold A. Dresser** has joined Sesler & Associates, Incorporated, engineers and constructors, Los Angeles, as manager of sales. The firm has formed Thermodynamic Equipment Company as a subsidiary with Dresser as manager for sales of heat generation and exchange equipment.

› **Mrs. Gail Nirdlinger,** Oakland, and **Charles H. Bodamer,** Berkeley, have joined the staff of Shell Development Company's Emeryville Research Center. Mrs. Nirdlinger is a mathematician in the applied mathematics department and Bodamer is an engineer in the experimental plants department.

› **C. W. Bates, H. T. Campbell,** and **C. T. Jones** have been promoted to senior supervising engineers in technical division at Humble Oil & Refining Company's Baytown, Texas, refinery.

Also promoted recently were **J. D. Brian** to senior coordination technician in Coordination Division; **C. W. Lubbock** and **Roger Wylie** to staff engineer; **D. L. Guthrie** to senior chemical engineer, and **T. B. Brister** to senior mechanical engineer in Technical Division.

C. L. Cox, J. F. Barker, and **D. D. Roselius** are new members of Technical Division.

› **Dr. Richard O. Norris** is new head of the materials division of Cities Service Research and Development Company's process research laboratory, Lake Charles, Louisiana. He formerly was research associate.

Other recent appointments include **Joe T. Kelly,** head of the process research division; **John J. Hagan,** senior research engineer, and **H. M. Knight,** senior research chemist. Kelly, Hagan, and Knight previously were associated with American Oil Company, at Texas City, Texas.

› **E. W. McNealy** has been appointed works manager of the Texaco Inc. refinery at Port Arthur, Texas. McNealy, formerly general superintendent of Port Arthur works, succeeds **Henry Flynn,** recently named general manager of the domestic refining department. **Jack C. Williams,** who was supervisor of the department's process and production division in New York, succeeds McNealy at Port Arthur.

› **Frank A. Leisey** has been appointed a senior project supervisor at the Whiting research laboratories of Standard Oil Company (Indiana). He will design and develop instruments for analyzing petroleum products in the refinery.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Continuous operation— a Teletype equipment tradition

All Teletype equipment . . . like the tape punches being final-tested above . . . are subjected to a rigorous quality-control program to insure that the units will give continuous, day-in, day-out performance in your service. Such performance is a Teletype tradition, established during more than fifty years of manufacturing data communications equipment.

To maintain this performance tradition requires much more than testing, however rigorous. It begins with the very design of the units themselves—the product of extensive research and development facilities, backed by cumulative experience. And it involves precision manufacture—employing the latest technological advances, from highly specialized machine tools and automated processes to electronic measuring and sensing devices.

When you select Teletype equipment to speed your communications and cut your paperwork costs, you can be sure of built-in quality. Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications systems.

Typing Tape Punch

Tape Reader

Send-Receive Page Printer

Automatic Send-Receive Set

FREE Model 28 line folder. Write Dept. 92E, 4100 Fullerton Avenue., Chicago 39, Illinois

TELETYPE®

CORPORATION

SUBSIDIARY OF *Western Electric Company* INC.

Edmonton, Alberta

CLOSE TO HOME, PUMP-WISE AND SERVICE-MINDED!

—Your Gaso Distributor

Casper, Wyoming

NEW YORK

Evansville, Ind.

TULSA, OKLAHOMA

Brookhaven and Tinsley, Miss.

Shreveport, La.

Wichita Falls, Texas

Odessa, Texas

Houston, Texas

Bakersfield, Cal.

Farmington, N. M.

Long Beach, Cal.

GASO DISTRIBUTORS BRING GASO SERVICE TO YOUR BASE OF OPERATIONS

We screen and pick our distributors with the utmost care. We bring their organizations to Tulsa for thorough training in oil-industry pumps and their application. We insist that they carry stocks of Gaso Pumps and parts.

Result: Complete Gaso service at your doorstep. Time-saving. Convenient. Still another explanation of the worldwide preference for Gaso Pumps.

GASO PUMP & BURNER MFG. CO.
FIRST and LANSING STS., TULSA, OKLAHOMA
EXPORT OFFICE: 2712 EMPIRE STATE BLDG.
NEW YORK, N. Y.

GASO PUMPS

for every oil industry need

SEND FOR OUR 1960-61 CATALOG

DISTRIBUTORS

Farmington, N. M. – Gaso Pump & Burner Mfg. Co. • Shreveport, La., Odessa, Texas, Brookhaven and Tinsley, Miss. – W. L. Somner Company • Houston, Texas – Texas Pump & Compressor Company • Wichita Falls, Texas – Pump Engineering Co. • Evansville, Ind. – Hague Equipment Co., Inc. • Long Beach and Bakersfield, Cal. – Power Pumps, Inc. • Casper, Wyoming – Lufkin Foundry & Machine Co. • Edmonton, Alberta – Lufkin Machine Co., Ltd.

When the trench hits rock bring in the Insley **M's**

When the trench hits rock, hills or swamps, put Insley's proven pipeline performance to work for you. Bring in the Insley M's. The M's modern wide-vision cab houses pipeline features unmatched by any other machine on the market. Take advantage of the "pipeline experience" that's designed into every Insley. Get all the facts today. Ask your Insley dealer for catalog 300-3 or write Insley direct. Or better still, see an Insley M in action. We'll make the arrangements at no obligation to you.

This 22 miles of trenching for 30-inch line runs between Ottawa and Welda, Kansas. The contractor, Vaughn & Taylor, Odessa, Texas, is using three ¾ cu. yd. Insley M's.

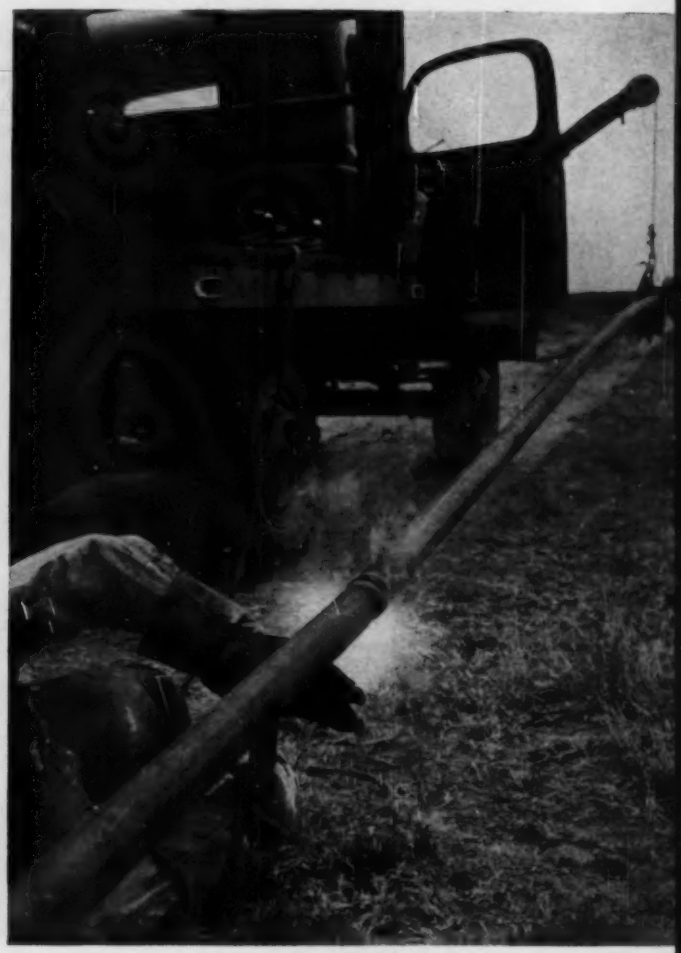
THERE'S AN **INSLEY** WORKING NEAR YOU

INSLEY MANUFACTURING CORPORATION • GENERAL OFFICES • INDIANAPOLIS 6, INDIANA

On the Job with

IN PENNSYLVANIA—Transco's 164-mile Leidy Line, connecting their main line with a new storage field in the north-central part of the state, requires some of the Bethlehem 24-in. pipe to be laid almost straight up.

IN NEW MEXICO—Utex Exploration Company and Charles A. Steen of Moab, Utah, build a gathering line by laying 3-in. Bethlehem buttweld pipe right on the surface of the ground.



Our new mills are geared to turn out pipe in larger tonnages than ever before. And it's line pipe that's thoroughly dependable, too. Every length is straight and true to round and bevel, right up to specs, and rigorously tested and inspected at the mill.

It's easy to check all the facts about Bethlehem Line Pipe—just call the Bethlehem sales office nearest you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA., *Export Distributor:* Bethlehem Steel Export Corporation

For strength
. . . economy
. . . eye-appeal

Steel

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Bethlehem Line Pipe

IN VIRGINIA—Commonwealth Natural Gas Corporation pushes a looping line through the tangled Blackwater Swamp. The Bethlehem 12¾-in. pipe weathered the construction battle perfectly.

FROM COLORADO TO CANADA—Pacific Northwest Pipeline Corporation's 1,487-mile main line required 13 compressor stations, each using Bethlehem 22- and 26-in. Mayari R high-strength pipe exclusively.

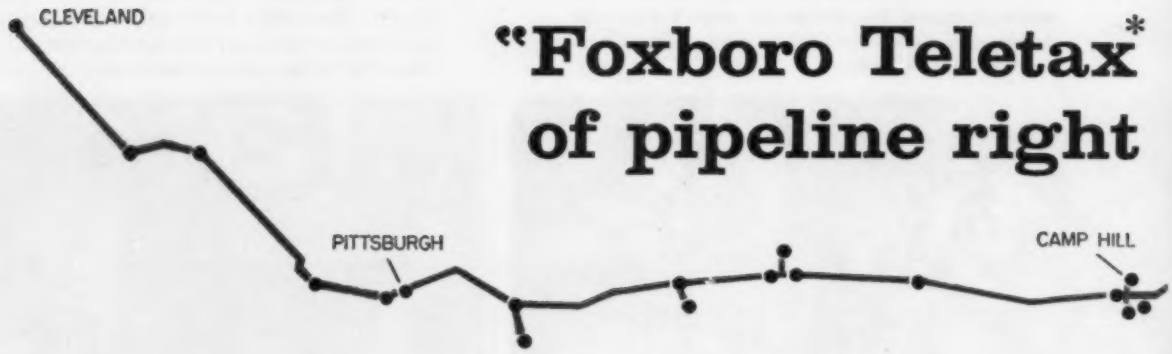
NOW AVAILABLE IN ALL SIZES MEETING API SPECIFICATIONS

	SIZES (in., OD, incl.)	WALL THICKNESS (in.)	LENGTHS	SPECIFICATIONS
HYDRAULICALLY EXPANDED ELECTRIC FUSION-WELD (submerged arc)	18 to 42	¼ to ¾ incl.	40 ft	API 5LX, Grades X42, X46 & X52 Also X-56 (non-API)
ELECTRIC RESISTANCE-WELD	5¾ to 16	API	to 60 ft	API 5L, Grades A & B API 5LX, Grades X42 & X46
CONTINUOUS BUTTWELD	½ to 4½	API	SRL 24 to 26 ft DRL to 50 ft	API 5L

BETHLEHEM STEEL

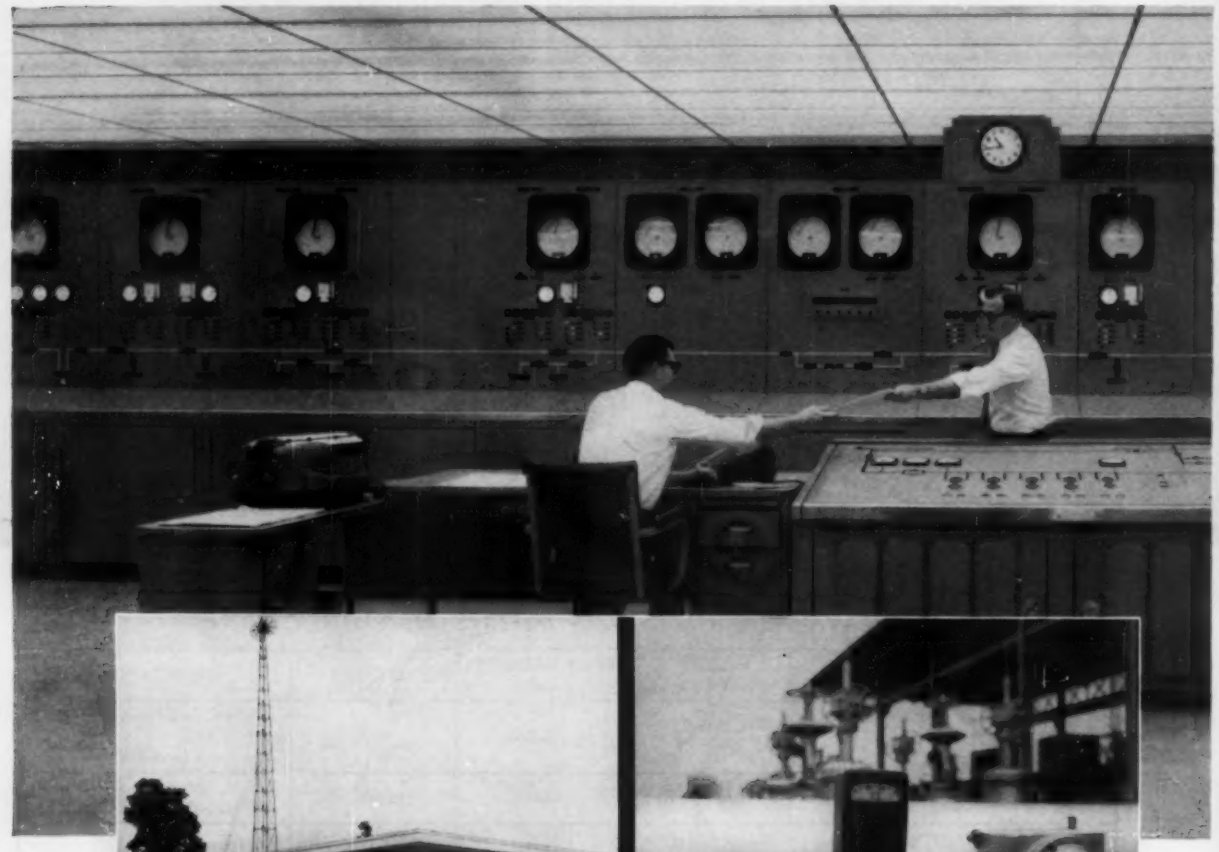
BETHLEHEM STEEL

Laurel Pipe Line Company reports:



"Foxboro Teletax* of pipeline right

447-mile Laurel Pipe Line Company is owned by the Gulf Oil Company, the Sinclair Pipe Line Company, and Texaco, Inc. Line serves 22 terminals between Philadelphia and Cleveland—has a capacity of 160,000 bpd.



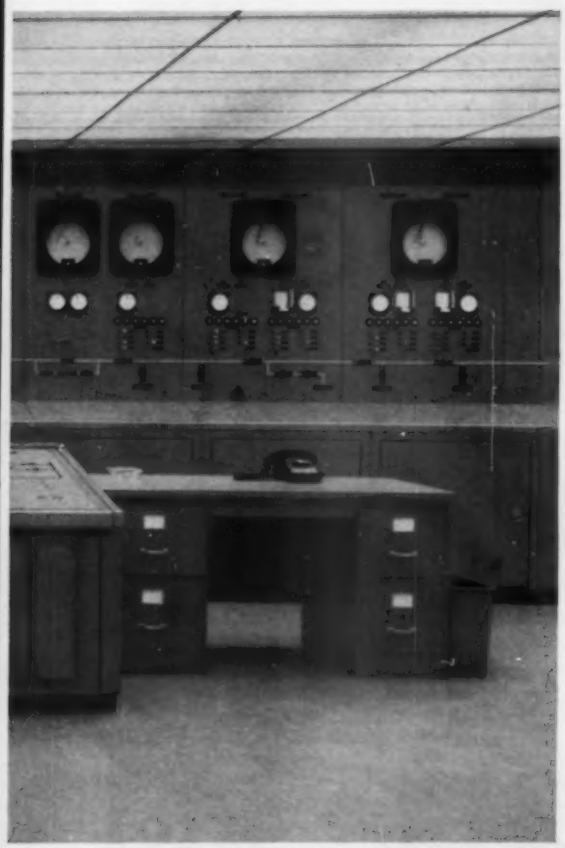
Central dispatching station at Camp Hill, Pa., is linked by microwave to the 62 Foxboro Teletax transmitters located along the 447-mile Laurel pipeline.

Foxboro M/44 pressure transmitter, sends signal to pumping station control room at rear while Teletax transmitter (in explosion-proof housing) beams pressure signal back to Camp Hill.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Telemetering puts 447 miles at our fingertips"

Deliveries to 22 terminals controlled from central dispatching station.



Foxboro Teletax Receivers on dispatchers' panel in Camp Hill, Pa., show 58 pressure and flow signals from pumping and metering stations along the line. Flow signals also go to totalizers on the boards, as well as to data logger next to dispatchers' desk.

PHOTOGRAPHY BY JOHN H. TROUP, JR., HARRISBURG

Picture a 24" to 14" pipeline starting in Philadelphia and ending in Cleveland, 447 miles away. Then picture 16 different petroleum products, belonging to 3 different oil companies, flowing to 22 delivery points. Picture this, and you understand the complexity of the Laurel pipeline.

To help Laurel dispatchers with their complex scheduling task, 62 Foxboro Teletax Telemetering Systems are employed. Transmitters are located at pumping and metering stations up and down the line; receivers at a central dispatching station in Camp Hill, Pennsylvania. Transmission is by company-owned microwave, supplemented at some locations by leased line circuits.

"Reliability was one of the chief concerns when installing our telemetering equipment," Laurel reports. "A high degree of reliability would allow us to adhere to predetermined delivery schedules — save pumping and manpower costs. In short, help operate the line more efficiently. And, with our Teletax systems, we've been getting that reliability."

Foxboro Teletax Telemetering systems are noted for their simplicity, their high sustained accuracy, as well as their reliability. They can be used with the most advanced transmission techniques. Write for Bulletin 17-11 — it gives all the details. The Foxboro Company, 385 Norfolk Street, Foxboro, Massachusetts.

*Reg. U.S. Pat. Off.

FOXBORO

REG. U.S. PAT. OFF.

CLEVELAND 320 TRENCHERS, digging in tandem, helped Panama, Inc. make up for time lost due to excessive rainfall on the 238-mile 30-inch Humble gas line from King Ranch to Clear Lake, Texas. Across the coastal plains the 320's, working singly, each averaged about a mile and a half of 6-foot-deep trench daily.

ON SMALLER DIAMETER LINES, the Cleveland Model 140 Trencher—shown at right digging a 38-mile gas extension in Idaho at well over 2 miles per day—has enjoyed a 30-year reputation among pipeliners for dependable low-cost production on jobs of all kinds, from field and gathering lines up through cross-country main lines up to 18" diameter.

Good Everywhere

The CLEVELAND TRENCHER Co.

20100 St. Clair Avenue • Cleveland 17, Ohio

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

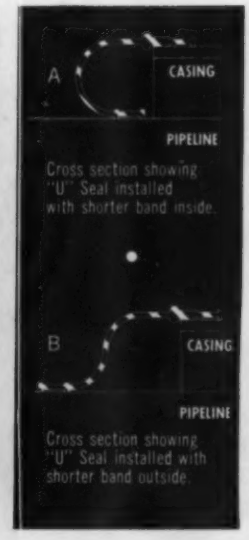
NEWS FROM DOWN THE LINE!

A NEW VERSATILE AND ECONOMICAL SEAL FOR CASED CROSSINGS...

THE NEW WmSON "U" SEAL

❶ "This new WmSon "U"-Seal maintains a tight seal regardless of what position the drag section assumes inside the casing."

❷ "This is a special demonstrator to show the flexibility of the "U"-Seal. Notice how it maintains its seal regardless of the change in pipe position in relation to the casing."



❸ " . . . Here the "U"-Seal is shown installed in the new "U" shape with the shorter band inside , which allows extreme flexibility. The "U"-Seal can also be installed with the shorter band on the outside in WmSon's familiar "Z" shape. In either case, only a screwdriver is needed to tighten the two stainless steel bands."

❹ Regardless of which way you install the "U"-Seal (Fig. A or fig. B) . . . . Regardless of what position the drag section assumes . . .

YOU CAN SEAL WITH A "U"-SEAL!

•

Write Dept. B for bulletin A-281

T.D. Williamson, Inc.

P. O. BOX 40 TULSA 2, OKLAHOMA

REPRESENTATIVES AROUND THE WORLD

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

now... three

PARTNERS IN JOHNS-MANVILLE PIPELINE PROTECTION

Now one single source takes on complete responsibility for any field wrapping job in pipeline protection! Johns-Manville manufactures wraps to meet every soil condition, every pipe wrap requirement. An enlarged staff of sales and technical personnel operates out of 13 sales offices . . . backed by modern research and development laboratories and 4 strategically-located plants. You can get further information by writing Johns-Manville, Box 158, Dept PE-5, New York City 16, or in Canada at Port Credit, Ontario.

1

FOR ENAMEL REINFORCEMENT

J-M BLUE FLAG WRAP

This wrap is specially-formulated from borosilicate type fiber glass that can't rot, decay or absorb moisture. Uniformly porous, Blue Flag allows enamel to bleed through quickly to minimize holidays and helps form an evenly distributed coating with high resistance to soil stresses. Adds years of protective life.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

2

FOR A TOUGH OUTER SHELL

J-M ASBESTOS FELTS

They resist soil stress, earth movement and rock pressures . . . withstand damage from handling, backfilling and other installation hazards. Felts are made of asbestos, a fibrous stone. In manufacturing, these fibers are felted, then impregnated with a coal tar or asphalt saturant to provide, literally, a flexible covering of stone.

JOHNS-MANVILLE J-M 7★

7-STAR VALUE PRODUCTS

3

AND NOW

J-M FLEXIBLE ROCK SHIELD!

It provides an added shield for pipe coating on lines running through rocky, rugged terrain. J-M Flexible Rock Shield is a tough asphalt mastic board . . . a resilient padding that forms an extra cushion against rupture and impact. J-M Flexible Rock Shield is a low cost way to prevent high cost maintenance problems.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

johnny on the spot!

with fast, expert 2-way radio service

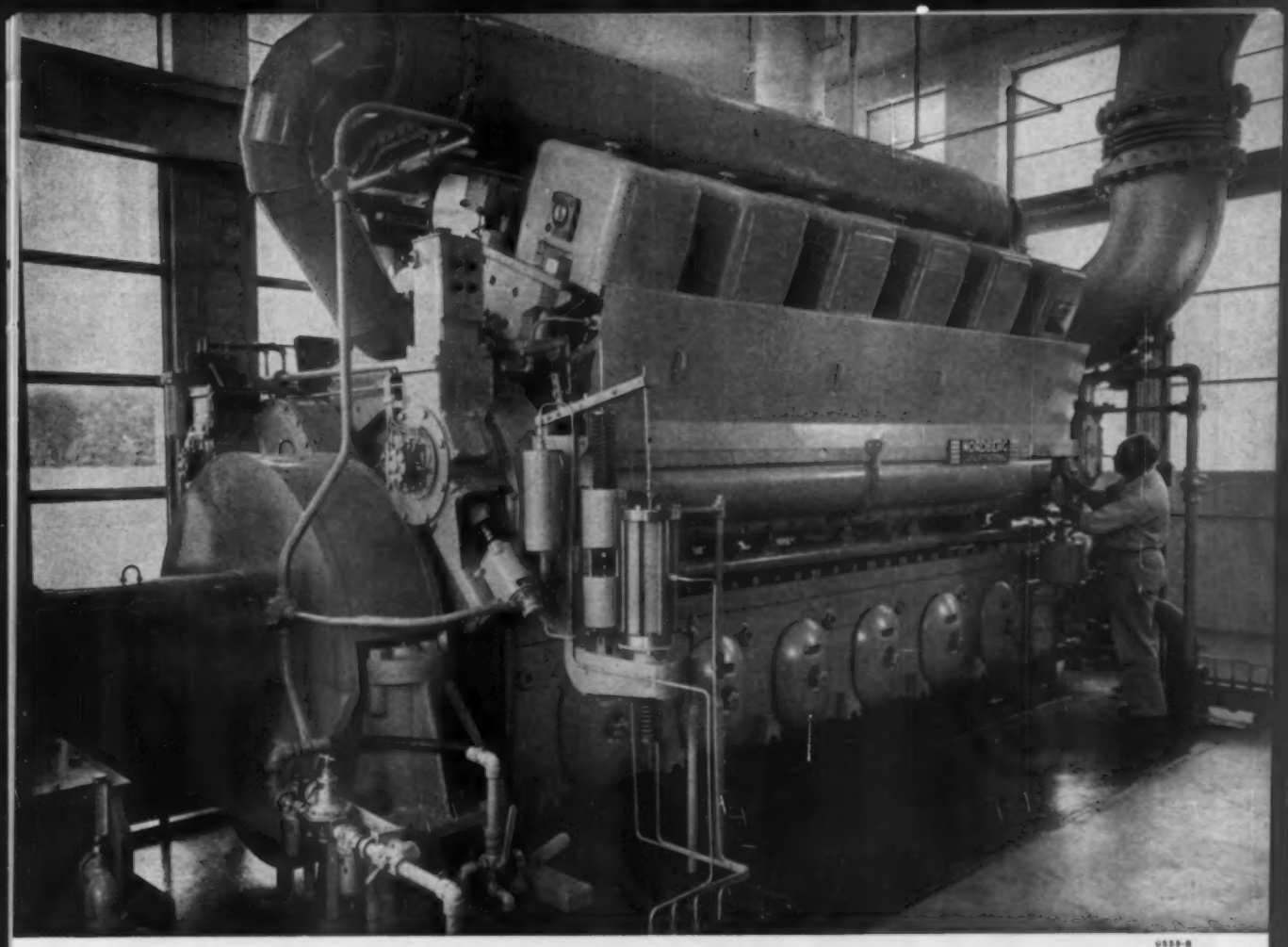
The surest way to protect the peak performance you paid for is to take advantage of Motorola's convenient 2-way radio system maintenance. You get *factory supervised* service to keep your equipment operating to *factory standards.*

Wherever you are, one of the more than 800 authorized Motorola Service Stations is your "Johnny-on-the-Spot"—ready to provide *complete* system service tailored to meet your specific requirements. Join the thousands of 2-way radio users who are now enjoying peak performance—and substantial long-run savings—with a Motorola maintenance agreement.

For the best in mobile radio . . . and the best in mobile radio service . . . better contact the man from Motorola. Why not call today for full facts?

MOTOROLA
2-WAY RADIO SERVICE

Motorola Communications & Electronics, Inc., 4501 Augusta Boulevard, Chicago 51, Illinois • A Subsidiary of Motorola Inc.



0559-B

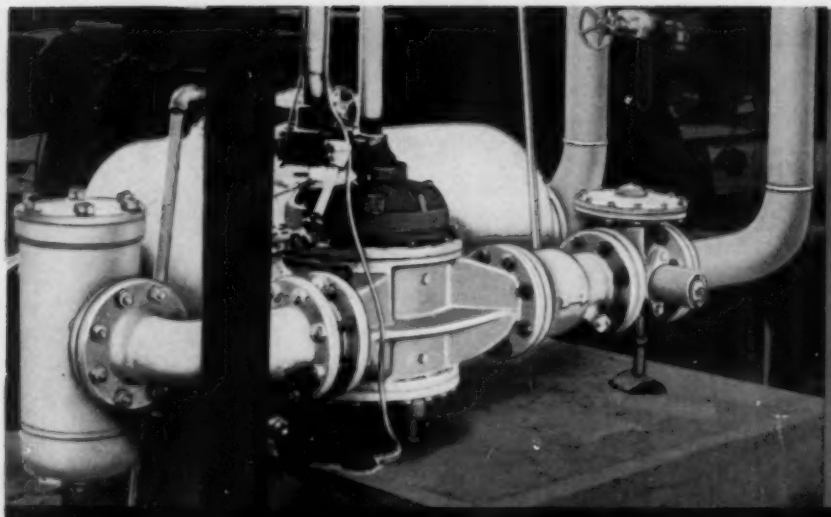
Pipe line engines by Nordberg

This compact, automatically-controlled Nordberg 2650 bhp four-cycle diesel engine furnishes all power for the Vicksburg, Michigan station of the Wolverine Pipe Line Company's 16" products pipe line. The engine drives a centrifugal pump through a speed increasing gear and flexible coupling.

NORDBERG MANUFACTURING COMPANY
MILWAUKEE 1, WISCONSIN

ATLANTA • CLEVELAND • DALLAS • DULUTH • HOUSTON • KANSAS CITY • MINNEAPOLIS
NEW ORLEANS • NEW YORK • ST. LOUIS • SAN FRANCISCO • TAMPA
WASHINGTON • TORONTO • VANCOUVER • JOHANNESBURG • LONDON • MEXICO D. F.

Continental Oil



SPECIAL PRODUCT LOADING
Three-inch S-35 Smith-Erie Meter assemblies equipped with temperature compensators, set stop valve, strainer, set stop mechanism and barrel counter. Printed meter ticket checks reading against refinery production.

LOADING TERMINAL
Approximately 30 Smith-Erie meters are in service loading products into trucks of Continental's customers, and tank cars for rail shipment. These meters are equipped with temperature compensators, deaerators, flow rate control valves, set stop mechanisms delivering gross gallons and printed tickets.

At Denver Terminal, separate Smith-Erie meter systems keep accurate accounting of all sales and transfers

Knowing the ins and outs and knowing them *exactly* is a must at complex product refinery-loading installations such as this one operated by the Continental Oil Company. Small wonder this progressive company "counts on" Smith-Erie meter systems for precise accounting of every drop of finished petroleum product regardless of operating conditions.

At Continental, knowing the ins and outs has a double meaning. Here, two separate operations go on simultaneously. One is intra-company distribution of the product from refinery to Continental trucks. The other is an out-sales situation involving transfer of product from refinery to trucks owned by Continental's customers. In both cases, Smith-Erie meters save costly manpower . . . provide for direct throughput . . . cut evaporation losses.

This Denver terminal is just one example of how Smith-Erie metering systems measure up to the most complex terminal requirements. For more information, contact your A. O. Smith meter man or write direct.

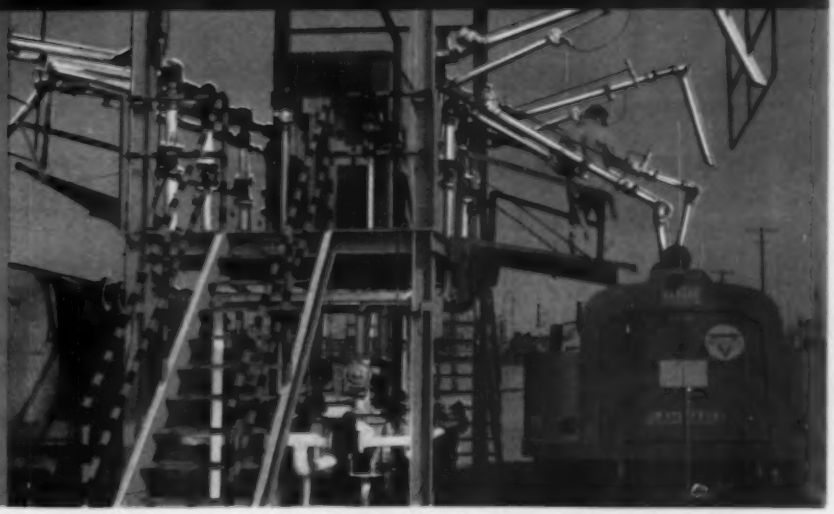
meters every drop

MARKETING STORAGE

Two Smith-Erie AS-35 and two AS-50 meter assemblies measure finished products from refinery production into tanks for Continental's own marketing division. Meters are equipped with temperature compensators, gross and net counters, set stop valves, deaerators and strainers. Readings are checked against refinery production and retail deliveries.

MARKETING DELIVERY

Four Smith-Erie AS-35 meters with accessories record loading of finished petroleum products into Continental trucks for delivery to Continental stations. This completes accurate record between manufacturing (refinery production) and deliveries against sales. Meters account for every drop and print a temperature-corrected record — automatically.



Through research ...a better way

A.O.Smith
CORPORATION
Smith-Erie Division

Factory: 1802 Wagner Ave., Erie, Pa. Offices: Atlanta 5, Ga.; Chicago 3, Ill.; Houston 2, Texas; Los Angeles 22, Calif.; New York 17, N. Y.; Oakland 21, Calif.; Tulsa, Okla. Canada: Toronto 12, Vancouver 1. A. O. Smith International S. A., Milwaukee 1, Wis., U.S.A.

THE GAR WOOD-BUCKEYE 318 PIPELINER WITH TORQMATIC CONVERTER DRIVE

Torque-converter equipped, the Gar Wood-Buckeye 318 gives you more ditch per day, more ditch per gallon of fuel than any other pipeline ditcher ever designed. Here's why:

With Torqmatic Converter Drive, operating speed in any gear range is maintained automatically—without shifting gears or changing throttle settings—even when the work load on the digging wheel varies as much as 40%. Engine torque is multiplied as needed—you get up to 2½ times more workpower, up to 20% more production each day. And since the engine works easier, maintenance and fuel costs are sharply reduced.

The 318 is more compact than any other ditcher of its capacity. You can load and transport it on a standard low boy. And built into the 318 are all Gar Wood-Buckeye standard-equipment "extras." Dual-drive hydraulic conveyor to handle any volume of spoil independent of all other operations. Hydraulic digging wheel hoist for on-the-go adjustments for depth and grade. Hi-Lo traction shift for one-lever control of traction speeds. Plus many others to put you ditcher dollars ahead.

You can get all the facts on the 318 by contacting your Gar Wood-Buckeye dealer. He'll be glad to prove to you why Gar Wood-Buckeye is the most famous name in ditchers.

Gar Wood
INDUSTRIES, INC.
Findlay, Ohio • Wayne, Michigan

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Charles Rutter, Chief Corrosion Engineer for the Equitable Gas Co., and Carl Barclay, Koppers serviceman, examine Bitumastic pipeline coating.

"Experience is what really counts and Koppers servicemen have plenty of it"

That's what Charles Rutter, Chief Corrosion Engineer for Equitable Gas Company, had to say about the services of Carl Barclay, Koppers serviceman, after the completion of Equitable's Farmington, West Virginia 16" gas line.

Mr. Rutter added, "That man knows all the ins and outs of pipeline coating and construction. He was on the job with the survey team before it was started and he stayed until the very finish. When our men came up against a problem they couldn't solve, Carl Barclay had the answer. You can't beat having a Koppers specialist on hand who has worked on every kind of coating problem there is."

Equitable's new line runs from Lumberport to Farmington, W. Va., and is part of a general expansion of the utility's facilities to meet the growing demand from customers in Western Pennsylvania and Eastern Ohio. The entire line was coated with Bitumastic No. 2 Enamel after cleaning and priming. For Carl Barclay this was another opportunity to put his experience to work—experience that includes pipeline work in every state of the Union and Canada.

When you are planning an expansion of your current pipeline facilities, it will pay you to specify Bitumastic coal-tar enamels —as well as performance-proved products, you'll get experienced counsel from Koppers. For more information send the coupon or write: Koppers Company, Inc., Tar Products Division, Pittsburgh 19, Pennsylvania. District Offices: Boston, Chicago, Los Angeles, Pittsburgh, New York and Woodward (Birmingham) Alabama, and in Houston, the Mavor-Kelly Co. In Canada: Koppers Products, Ltd., Toronto, Ontario.

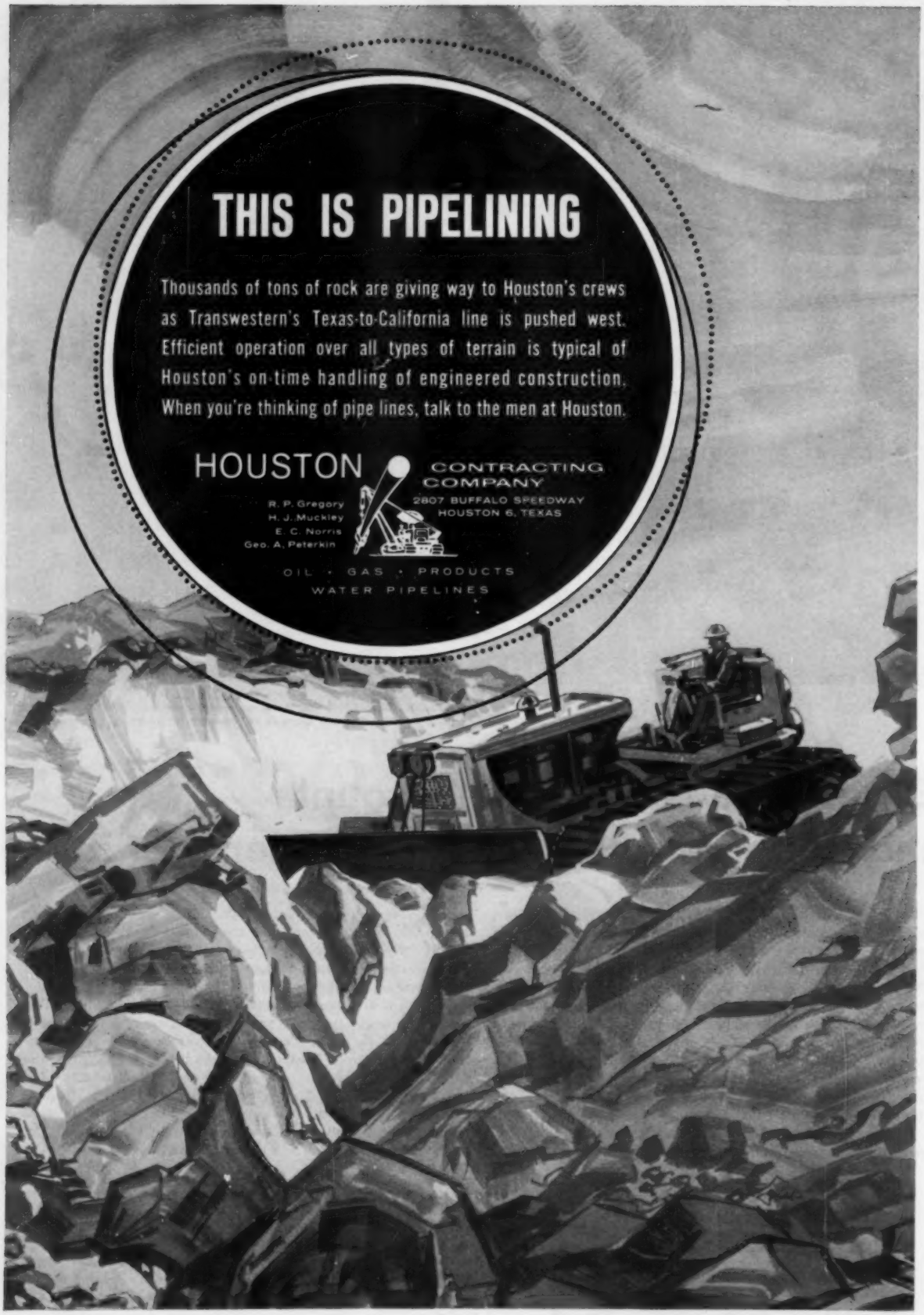
KOPPERS

KOPPERS
BITUMASTIC
COATINGS AND ENAMELS
another fine product of COAL TAR

Koppers Company, Inc., Tar Products Division
Dept. 105-E, Pittsburgh 19, Pa.

Gentlemen:
I would like a copy of your booklet on pipeline coatings, "How Long Should A Pipeline Last?"

Name_____ Title_____
Firm_____
Address_____
City_____ Zone____ State_____


THIS IS PIPELINING
Thousands of tons of rock are giving way to Houston's crews as Transwestern's Texas-to-California line is pushed west. Efficient operation over all types of terrain is typical of Houston's on-time handling of engineered construction. When you're thinking of pipe lines, talk to the men at Houston.
HOUSTON
CONTRACTING COMPANY
2807 BUFFALO SPEEDWAY
HOUSTON 6, TEXAS
R. P. Gregory
H. J. Muckley
E. C. Norris
Geo. A. Peterkin
OIL • GAS • PRODUCTS
WATER PIPELINES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

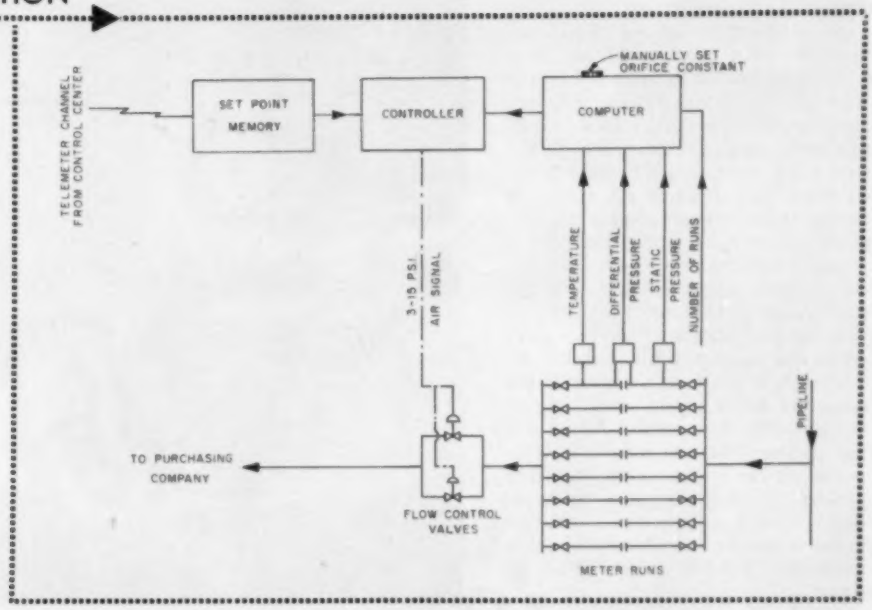


FIG. 1. Schematic of delivery measuring station.

One-Man System Operation

Columbia Gulf employs four types of computers, and related telemetering and control equipment, on its almost completely automated pipeline

M. M. Levy, *Project Engineer*
Columbia Gulf Transmission Company

AUTOMATIC OPERATION of a natural gas pipeline requires the use of several types of computers. Four types are used in the operation of Columbia Gulf Transmission Company's system.

For purposes of this article, a computer may be defined as an "electrical device that performs arithmetic calculations automatically." These computers have played an important role in the automation of Columbia Gulf's facilities.

One type of computer is that installed at the two delivery measuring stations through which flows all gas delivered by Columbia Gulf. These measuring stations are at Leach and Means, Kentucky. Because of the requirements of the purchasing company, it is necessary to shift deliveries between the two stations.

Prior to automation, each delivery station required one man in attendance at all times to receive telephone orders from the gas control supervisor in Nashville, Tennessee, in order to effect a change in flow. Installation of automation equipment now enables the gas control supervisor to send a new flow order indicating the change in delivery requirements as changes in demand occur. The link between Nashville and the two delivery measuring stations is by leased telephone circuit.

Delivery Station Operation

An example will explain the operation of this type computer. Assume that the flow through a measuring station is 300,000,000 std cu ft per day, and the new quantity of gas to be delivered at this point is 360,000,000 std cu ft per day. The number "360" is dialed into the control panel at Nashville and is transmitted digitally by a 24-step pulse code to the measuring station.

At the delivery measuring station, an analog computer is installed. The data input to the computer consists of the differential pressure across the orifices of the meter runs, static pressure, gas temperature, and the number of runs that are in service. In addition, the orifice constant is manually set into the computer. Fig. 1 shows a schematic of equipment at the measuring stations.

The computer output in MMSCFD is compared with the set point (now 360,000,000 std cu ft per day) telemetered from the gas control center at Nashville. As the set point is now greater than the flow through the station, the air signal from the controller is increased, opening the flow control valves and allowing a greater quantity of gas to flow through the station.

In addition, to assure accurate measurement, when the differential pressure reaches 80 in. of water, a meter run valve automatically opens, placing an additional run in service. Conversely,

when the differential falls to 20 in., a meter run valve will close.

As an example, assume that when the differential reaches 80 in., flow through the station as indicated by the computer is 340,000,000 std cu ft per day. Let us suppose that with the meter run valve open, the flow through the station will increase to 420,000,000 std cu ft per day. Because the computer output is now greater than the set point, the air signal to the flow control valves will be reduced, the valves will close slightly, and the flow through the station will be reduced. The air signal will become stabilized at the point where the computed flow matches the desired flow. So long as none of the computer datum input changes, the air signal to the flow control valves will not change. There is automatic compensation for variations in the static pressure or gas temperature that might occur, as such variations cause changes in the computer output, which in turn cause the controller to change the air signal.

Computers at the two delivery measuring stations have magnetic amplifiers and transistors as their major components. An accuracy of approximately 0.5 percent of the range of the computer (1,000,000,000 std cu ft per day) is obtained.

Accuracy Can be Checked

Excellent results have been obtained with the delivery measuring station computers; however, the gas control supervisor is provided with a means of insuring their accuracy automatically. The differential pressure, static pressure, gas temperature, and the number of runs in service are telemetered digitally to the gas control center.

An all-relay digital computer receives this information and computes the flow to the nearest MMSCFD. The equipment computes the new flow rate on change of any one of the variables. The gas control supervisor then compares the computed flow as determined by the all-relay digital computer with the desired flow at the delivery measuring station. The digital computer not only computes the flow through the delivery measuring stations, but also through the five centrifugal compressor stations and four measuring stations on the gathering lines.

This digital computer is an all-relay system for the special use of calculating gas flow based on the standard gas flow formula:

$$F = CN\sqrt{DP \times SP + 15}$$

Where:

F = flow,
C = orifice constant,
N = number of runs,
DP = differential pressure, and
SP + 15 = static pressure brought to absolute.

The datum (runs, differential pressure, and static pressure) for all compressor and measuring stations for the pipeline are gathered and stored in digital form at Nashville. The computer accepts the information stored in the form of decimal binary, translates it to straight binary, performs the mathematical flow formula computation, and translates back to decimal binary in order to digitally display flow.

Mathematical Computation

The mathematical computation is based on the use of binary adders, binary logarithms to the binary base 2, and binary register shift. Since a relay is a two state device of very high reliability and multiple circuit capabilities, it forms a perfect tool in the form of a binary adder.

Examination of the flow formula shows that if written in logarithmic form, the binary addition is the only primary manipulation necessary:

$$\text{Log } F = \frac{\log C + \log DP + \log(SP + 15)}{2}$$

The division by 2 is the only exception to the use of the binary adder manipulation. If the logarithms are in binary form, then division by 2 is simply a case of register shifting one position and is therefore a wiring function only and requires no equipment. Computation requires approximately one second with a resultant accuracy of better than 0.1 percent.

Calculating Horsepower

Calculation of horsepower developed at a centrifugal compressor station is a somewhat tedious and time consuming task. Consequently, a computer is installed in Columbia Gulf's gas control center to relieve the gas control supervisor of lengthy calculations. This computer, shown in Fig. 2, is an analog computer utilizing magnetic amplifiers in which the program is fixed.

Values are fed into the computer manually by setting the dials on the various potentiometers. Station suction pressure and temperature, number of engines running, flow through the station, engine speed, and compressor

FIG. 2. Horsepower computer.

M. M. Levy *was graduated from Texas A&M College with a BS degree in mechanical engineering (1949). After graduation, he worked with an oil field service company for four years. In 1953, he was employed by Gulf Interstate Gas Company, and was active in the design and construction of Gulf Interstate's first automated compressor station constructed at Stanton, Kentucky, in 1955. When Gulf Interstate became Columbia Gulf Transmission Company in January, 1959, he was made compressor station project engineer. He is a registered professional engineer in the state of Texas.*

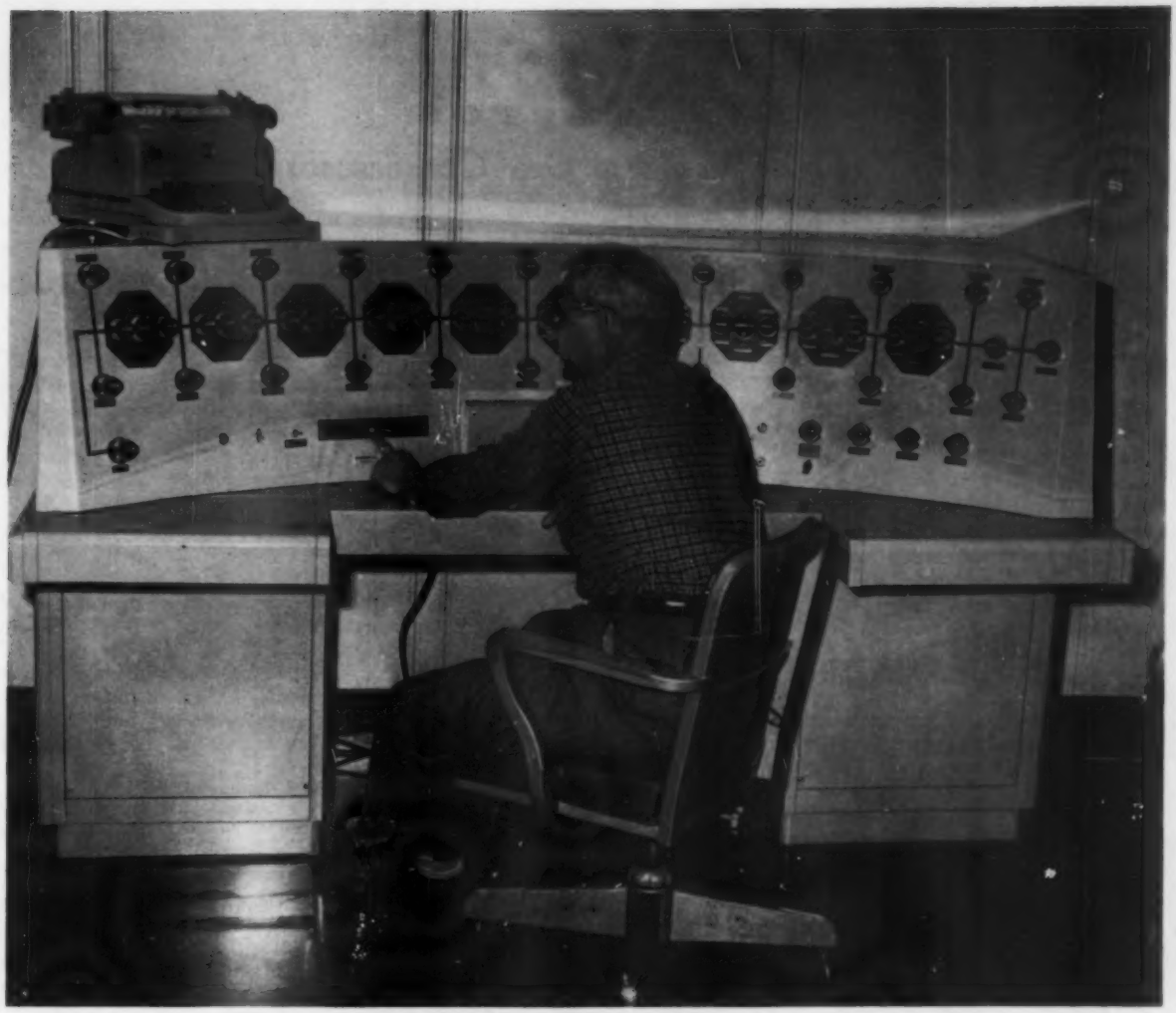


FIG. 3. Flow study computer.

wheel characteristics are dialed into the computer. Except for compressor wheel characteristics, all required information is displayed digitally on the gas control center control panel. Any change in these values is indicated on the control panel automatically as the information is received from the field locations.

When the necessary information has been dialed into the computer, the gas control supervisor can read the following values on the appropriate meters: Engine horsepower, engine brake mean effective pressure, compressor efficiency, and fuel consumption of the engine at the given conditions. As this is an analog computer, any change in the data input will result in an instantaneous change in output values. In this manner, the supervisor is able to tell what will occur at a compressor station for any change planned in the station discharge pressure or in the number of engines in service.

Early in the automation program of Columbia Gulf Transmission Company, it was realized that in order to operate the pipeline satisfactorily with one gas control supervisor, it would be necessary to provide him with the proper tools to take care of any eventuality quickly and efficiently. One of these tools is the horsepower computer. Another aid is a flow computer that automatically calculates flow studies, which, if done manually, are very time consuming.

System Conditions Simulated

On the flow study computer shown in Fig. 3, the gas control supervisor can simulate actual conditions on the entire pipeline. For each section of the system, he is able to vary any of the following inputs: Discharge pressure at the compressor station, flow through the station, and fuel factor. The equivalent length of pipe in a particular section may also be changed when that section is looped. He also can change the average flowing temperature and the pressure base. With the inputs, the gas control supervisor can obtain the following information: Suction pressure at each station, required station horsepower, fuel consumption at each station, and station compression ratio. When all input datum are set into the computer, the operator presses a switch and the inputs and outputs are printed on an automatically operated electric typewriter. Accuracy of this computer is in the order of 0.5 percent.

Installation of the computers and the related telemetering and control equipment has allowed Columbia Gulf Transmission Company to eliminate eight shift personnel formerly assigned to the two delivery measuring stations. Computers also have freed the gas control supervisors from tedious calculations and have made possible one-man operation of Columbia Gulf Transmission Company's pipeline. ★ ★ ★

Operating Curves

Developed for Natural Gas Compressors

Load characteristics presented in practical manner for reciprocating and centrifugal machines

Henry B. Martch, Jr. **Jack T. Watzke**
El Paso Natural Gas Company

EFFICIENT OPERATION of natural gas pipeline compressor units requires that the prime mover be operated as closely to its rated load as possible. This can be accomplished if compressor load characteristics are available. The development of these characteristics is a tedious, time-consuming task if calculations are performed by hand. The use of a computer relieves the engineer of this burden and makes practical a more useful presentation of load characteristics.

Reciprocating Compressors

Fig. 1 shows a plot of compressor horsepower as a function of suction pressure at a constant discharge pressure. This method of presentation is frequently used; however, it requires the preparation of several graphs to show the performance over a range of discharge pressures.

From an operator's viewpoint, this method of presentation may not be desirable. A more useful presentation has been suggested by Tateosian and Brooks[1] and is shown in Fig. 2. This plot displays constant compressor horsepower as a function of suction and discharge pressures.

The equations used to develop Fig. 1 and 2 are those used by one particular compressor manufacturer.[2] Equations used by other manufacturers will differ from these in some respects.

$$E_v = 100 - R - Cl\,(r^{1/k} - 1) \quad . \quad . \quad . \quad . \quad (1)$$

$$PD = \frac{(S)(RPM)(2)}{1728}\left[A_{he} - \frac{A_r}{2}\right] \quad . \quad . \quad (2)$$

$$BHP = (PD)(E_v)(P_1)(BHP/M^3CFD) \times 10^{-4} \quad . \quad (3)$$

Where:

E_v = Volumetric efficiency of the compressor cylinders, percent
r = Compression ratio
Cl = Compressor cylinder clearance, percent
k = Ratio specific heats of the gas
PD = Piston displacement per compressor cylinder, cu ft per min (double acting cylinder)
S = Stroke of the compressor, in.
RPM = Speed of compressor in revolutions per minute
A_{he} = Area of piston, sq in.
A_r = Area of rod, sq in.
BHP = Brake horsepower required from the prime mover
P_1 = Suction pressure, psia

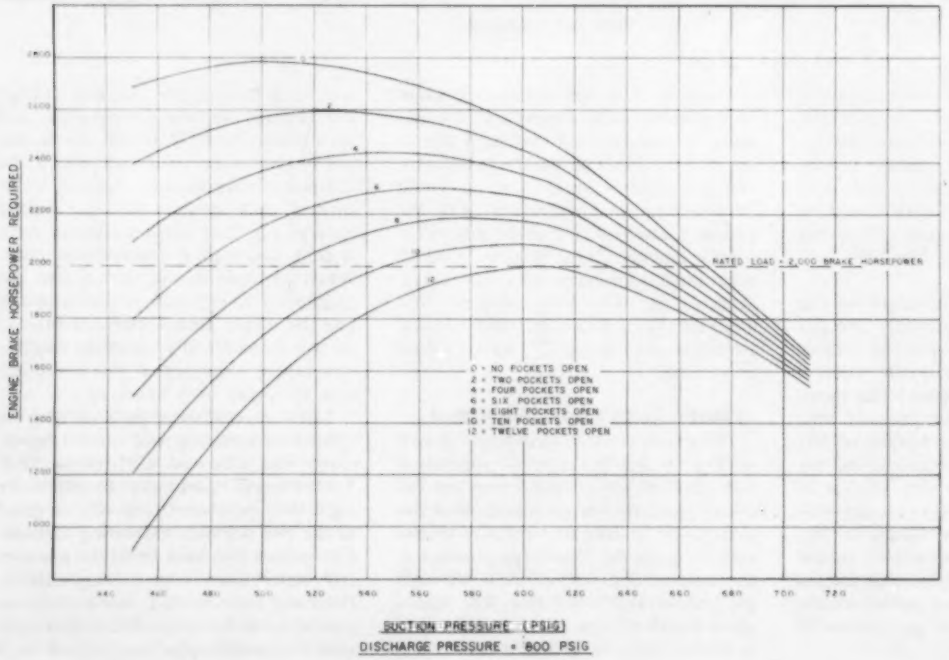

ENGINE BRAKE HORSEPOWER REQUIRED
RATED LOAD - 2,000 BRAKE HORSEPOWER
0 - NO POCKETS OPEN
2 - TWO POCKETS OPEN
4 - FOUR POCKETS OPEN
6 - SIX POCKETS OPEN
8 - EIGHT POCKETS OPEN
10 - TEN POCKETS OPEN
12 - TWELVE POCKETS OPEN
SUCTION PRESSURE (PSIG)
DISCHARGE PRESSURE = 800 PSIG

Fig. 1. Reciprocating compressor load characteristics. Constant discharge pressure: 800 psig.

BHP/M^2CFD = Brake horsepower required to compress 1 million cu ft of gas per day. (Standard base is 14.4 psia and suction temperature.)

The computer solution of equations for single stage compression, as well as multi-stage compression, has been thoroughly covered prior to this writing; thus, these reciprocating compressor curves and calculations are included merely to serve as a background for the development of similar curves for centrifugal compressors.

Centrifugal Compressors

The conventional method of presenting centrifugal compressor performance is shown in Fig. 3. This presentation is of little value to the operator unless numerous supplementary curves are provided for converting pipeline conditions into centrifugal compressor terminology. By using the following equations, the horsepower required at various operating conditions can be computed and plotted as shown in Fig. 4.

$$H = Z_1 R T_1 \frac{k}{k-1}\left(r^{\frac{k-1}{k}} - 1\right). \quad . \quad . \quad . \quad (4)$$

$$d_1 = \frac{144 P_1}{R\, T_1 Z_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$w = d_1 Q_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$BHP = \frac{wH}{33{,}000\, E_m E_1} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Where:

H = Head, ft-lb/lb
Z_1 = Compressibility factor at inlet conditions
R = Specific gas constant, ft-lb/lb-deg Rankin
T_1 = Inlet gas temperature, deg Rankin
k = Ratio of specific heats
r = Compression ratio
d_1 = Gas density at inlet conditions
P_1 = Inlet pressure, psia
T_1 = Inlet temperature, deg Rankin
w = Gas flow, lb/min
Q_1 = Inlet gas flow, ft^3/min
BHP = Brake horsepower
E_m = Mechanical efficiency of speed increaser × mechanical efficiency of compressor
E_1 = Isentropic efficiency

These equations are developed in a number of books covering the subject of centrifugal compressors.[3]

Centrifugal performance calculations have been programmed for the IBM 650 computer. SOAP II programming techniques are employed to minimize computing time.

The computer program determines the compression ratio, and with the aid of Equation 4 converts this ratio to head. The resulting head with its corresponding throughput (Q_1) and isentropic efficiency (E_1) are then combined as shown in Equations 5 to 7, to determine prime mover horsepower. In order to perform these computations, the computer must be provided with the relationships of throughput (Q_1) with head (H) and isentropic efficiency (E_1).

Values are obtained from a suitable performance curve such as Fig. 3 to obtain the following table of performance:

CFM	$Head_A$	$Head_B$	$Head_C$	E_{1A}	E_{1B}	E_{1C}
5000	8050	8150	8250	0.7575	0.7575	0.7500
5100	8025	8125	8225	0.7600	0.7600	0.7500

Where $Head_A$ and E_{1A} are values related to a particular guide vane setting. This table is then punched into standard IBM cards requiring one card for each line in the table. The data is entered on a 5.5 decimal basis requiring the use of card columns 1-70, the remaining columns 71-80 are unused and should contain zeros.

In addition to the performance table cards, the following 10 load cards are required to describe the conditions under which the compressor performance is to be evaluated. Each entry is stored on a 5.5 decimal basis within the computer.

1. Identification code
2. Ratio of specific heats (k)
3. Specific gravity (G)
4. Suction temperature (T_1)

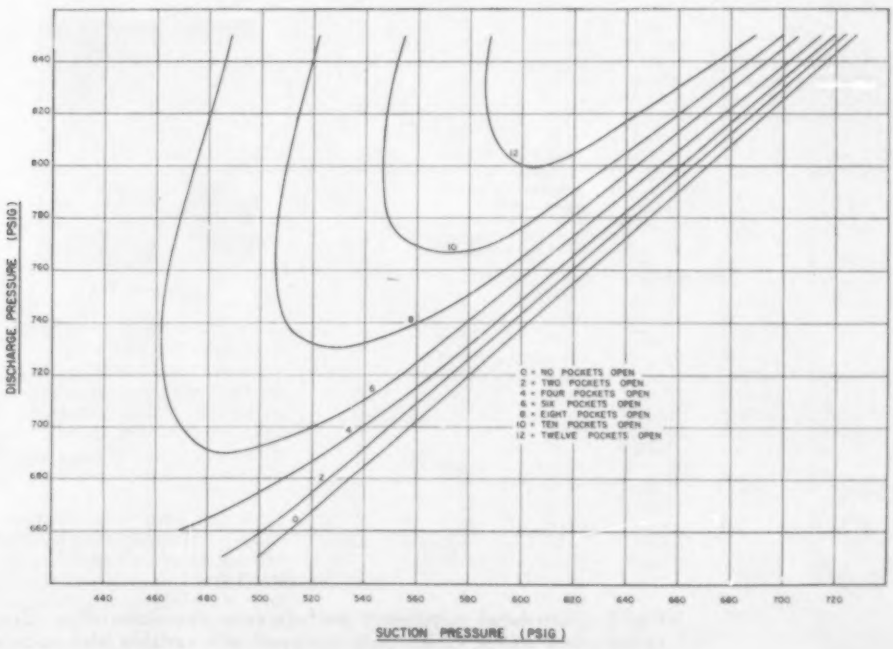

DISCHARGE PRESSURE (PSIG)
SUCTION PRESSURE (PSIG)
0 = NO POCKETS OPEN
2 = TWO POCKETS OPEN
4 = FOUR POCKETS OPEN
6 = SIX POCKETS OPEN
8 = EIGHT POCKETS OPEN
10 = TEN POCKETS OPEN
12 = TWELVE POCKETS OPEN

Fig. 2. Reciprocating compressor operating curves. Constant rated load: 2000 brake horsepower.

5. Suction pressure (P_1)
6. Discharge pressure (P_2)
7. Incremental suction pressure (ΔP_1)
8. Incremental discharge pressure (ΔP_2)
9. Number of variations of ΔP_1
10. Number of variations of ΔP_2

The compressor program, performance table, and operating conditions cards are read into the computer in that order with the aid of an IBM 533 control panel wired to read and punch on a standard 80-80 configuration. The program will compute each value of head, horsepower, and throughput in less than 0.6 seconds, enabling the IBM 533 read-punch unit to operate at punch speed.

The output cards are then listed with descriptive cards on the IBM 407 printer, thus preparing the report shown in Fig. 5. It should be noted that the throughput has been converted to MMSCF/D at 14.9 psia and 60 F.

Although the example described pertains to a constant speed electric motor-driven compressor, the same general procedure can be used for variable speed compressors.

Because the presentation of centrifugal compressor performance shown in Fig. 3 is useful to the compressor designer, it may be of interest to note that the IBM 650 can be adapted to the development of these curves from compressor test data.

The test data that is required is:

1. Compressor inlet pressure in psia
2. Compressor inlet temperature in deg Rankin

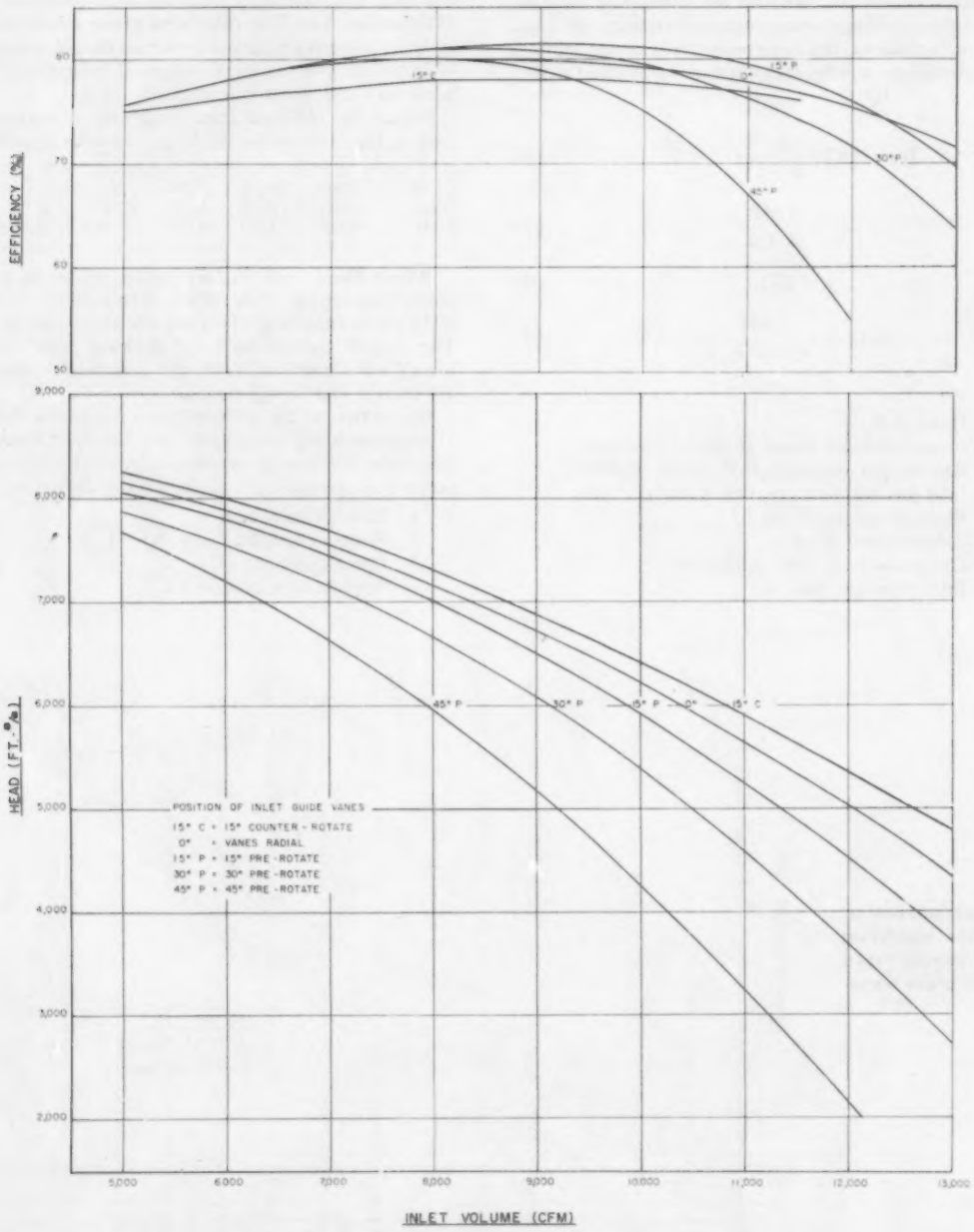


Fig. 3. Centrifugal compressor performance characteristics. Constant speed prime mover. Compressor equipped with variable inlet guide vanes.

3. Compressor outlet pressure in psia
4. Compressor outlet temperature in deg Rankin
5. Analysis of the gas compressed
6. Inlet flow in CFM

From these test data, it is desired to determine the compression efficiency and the head developed as a function of throughput.

A program of the Benedict, Webb, and Rubin Equation of State[4] determines the changes in enthalpy and entropy between inlet and outlet condition and also the enthalpy change for a constant entropy compression.

The efficiency is then the ratio of the isentropic enthalpy change to the actual enthalpy change and by converting the units of enthalpy (Btu/lb) to units of head (ft-lb/lb) the actual head developed is determined.

It is apparent that Fig. 2 and 4 provide compressor operators with a complete guide to the operation of his equipment. These curves may be reduced to a tabular form for those who find tables more convenient to use. In any event, the curves provide an additional service to those engineers interested in the design of automatic compressor control systems. Thus the computer continues to provide a rapid means of study for those problems that confront the natural gas engineer.

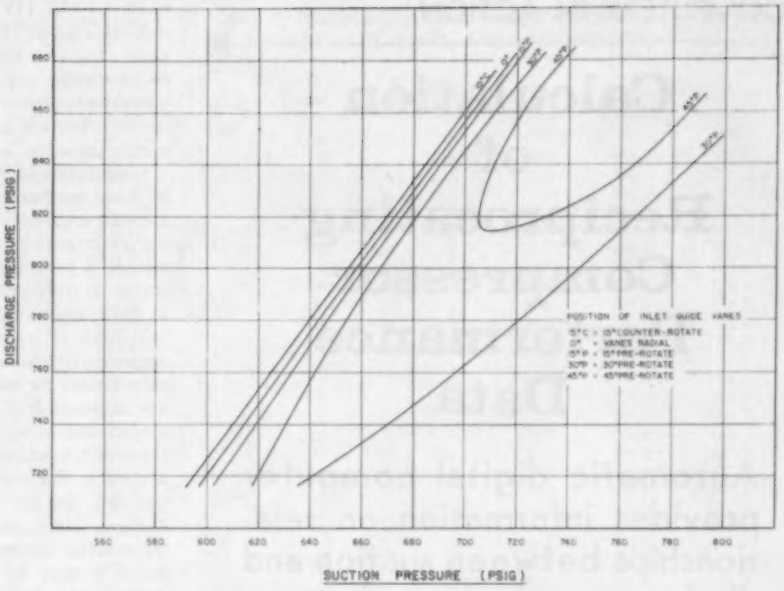


Fig. 4. Centrifugal compressor operating curves. Constant rated load: 5000 hp. Constant speed prime mover.

FIG. 5. Centrifugal compressor calculation report.

CENTRIFUGAL PERFORMANCE CALCULATIONS

Code	K	G	T1		
2020.000	1.275	.630	520.000		
	P1	P2	Head		
	690.000	840.000	7832.415		
		Vane set	HP	CFM	MMSCFD
		15.000	4730.160	5870.340	442.137
			4954.535	6170.340	464.727
		15.000	5355.928	6535.170	492.203
	P1	P2	Head		
	700.000	840.000	7236.368		
		Vane set	HP	CFM	MMSCFD
		15.000	5478.435	7477.263	572.273
			5784.551	7827.263	599.062
		15.000	6180.930	8154.526	624.108
	P1	P2	Head		
	710.000	840.000	6652.568		
		Vane set	HP	CFM	MMSCFD
		15.000	5909.309	8694.864	676.090
			6366.664	9194.864	714.963
		15.000	6721.890	9494.864	738.294
	P1	P2	Head		
	690.000	850.000	8316.217		
		Vane set	HP	CFM	MMSCFD
		15.000			
		15.000			
	P1	P2	Head		
	700.000	850.000	7714.009		
		Vane set	HP	CFM	MMSCFD
		15.000	4991.879	6221.981	476.197
			5220.630	6543.962	500.840
		15.000	5611.596	6871.981	525.950
	P1	P2	Head		
	710.000	850.000	7130.209		
		Vane set	HP	CFM	MMSCFD
		15.000	5655.131	7739.582	601.811
			5977.047	8079.164	628.214
		15.000	6403.782	8439.582	656.235
	P1	P2	Head		
	690.000	860.000	8791.830		
		Vane set	HP	CFM	MMSCFD
		15.000			
		15.000			
	P1	P2	Head		
	700.000	860.000	8191.688		
		Vane set	HP	CFM	MMSCFD
		15.000			
		15.000	4654.437	5233.246	400.528

★ ★ ★

[1]Tateosian, C. J. and Brooks, R. W., "Development of Compressor Operating Charts for Gas Compressor Stations," paper presented at Technical Services Conference of the Pacific Coast Gas Association, March 1952.

[2]The Cooper-Bessemer Corporation, *Reciprocating Compressor Calculation Data*, Mount Vernon, Ohio.

[3]Stepanoff, A. J., *Turboblowers*, New York; John Wiley and Sons, Inc. 1955.

[4]Benedict, M., Webb, G. B., and Rubin, L. C.; "An Empirical Equation for Thermodynamic Properties of Light Hydrocarbons and Their Mixtures", *Chemical Engineering Progress*, Volume 47, No. 8, pp. 419-422, August 1951.

H. B. Martch

J. T. Watzke

Henry B. Martch *obtained a bachelor of science degree in electrical engineering in 1953. After a tour of duty with the armed forces, he was employed by Radioplane Company as an autopilot engineer. Since 1957, he has been with El Paso Natural Gas Company employed as an analyst in their pipeline and compressor design department. He specializes in the development and application of computer programs to those engineering problems that confront his company.*

Jack T. Watzke *received a bachelor of science degree in electrical engineering from Texas Western College. He has been employed by El Paso Natural Gas Company for the last seven years serving in the following departments: Pipeline design, technical service, research and development, and compressor station design. He is a member of AIEE and ISA and is a registered professional engineer.*

Calculation of Reciprocating Compressor Performance Data

Automatic digital computer provides information on relationships between suction and discharge pressures, compressor volumetric capacity, and engine load

R. L. Ridings
Texas Eastern Transmission Corporation

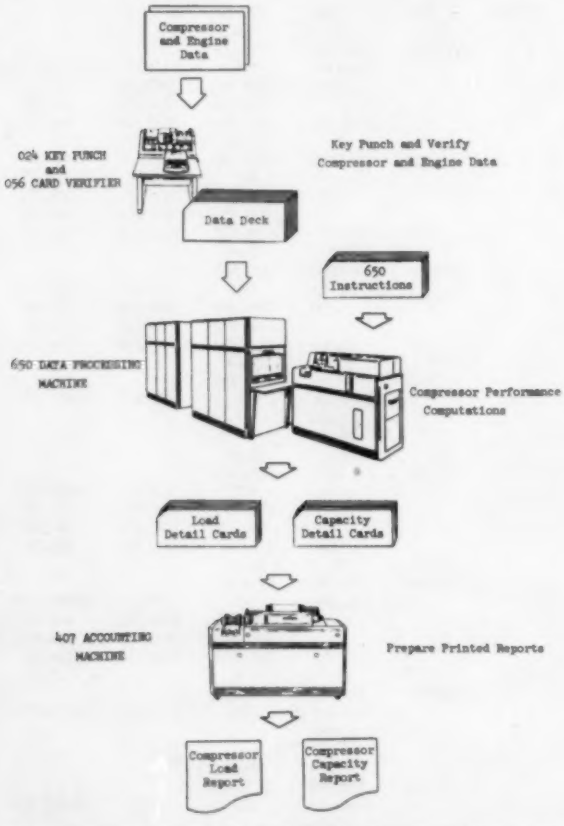


FIG. 1.

FOR EFFECTIVE OPERATION of gas compressor stations, operating personnel need information on performance characteristics of the compression equipment. For reciprocating gas compressors, this information generally takes the form of operating charts showing the relationships between suction and discharge pressures, compressor volumetric capacity, and engine load.

Calculation of reciprocating gas compressor performance by hand methods is tedious and relatively complicated. As a result engineers employ short-cut methods involving the use of intermediate curves to reduce the hand calculation time to a practical minimum. Also, the tendency is to calculate as few points as necessary to indicate trends and to draw approximate curves based on these points.

Advent of automatic electronic computers has enabled engineers to release a great deal of monotonous and laborious calculations to machines. Experience with these machines has demonstrated great improvements in accuracy, time required and completeness of the computations. That is, it is possible to calculate more cases in less time with improved accuracy. Perhaps even greater advantage is achieved by enabling the use of new methods of solving the problems at hand. Often, although it is possible to derive great benefits by making automatic the calculations now performed by hand, it may be of much greater benefit to change the method of solution to take advantage of ideas that could not be practically applied to the hand calculation methods.

Automatic computation of reciprocating gas compression units at Texas Eastern has been found highly desirable. The computations involved were programmed for an IBM 650. In order to get the most benefit from the computer application, it was necessary to change the method of attacking the problem. The method developed eliminates the necessity for the output of intermediate results and the drawing and interpretation of curves plotted from these intermediate results. The developed method is described in a later part of this article.

Procedure

Data on the compression unit required for the computations are as follows:

1. Identification of the unit to be used to relate data, punched cards and printed reports.
2. Compressor cylinder bore diameter.
3. Number of compressor cylinders.
4. Rod diameter.
5. Length of stroke.
6. Fractional clearances of head end and crank end with no pockets open.
7. Types and volumes of head-end and crank-end pockets.
8. Rated horsepower of engine.
9. Engine speed.
10. Minimum, maximum, and increment to be used for suction pressure, discharge pressure, volumetric capacity, and engine load.
11. Pocket conditions for each set of calculations desired.

Fig. 2. Reciprocating Compressor Performance Calculation Output from "Load" Phase — Compression Unit "X"

Head end pockets open		Crank end pockets open		Engine load percent	Suction pressure psi	Discharge pressure psi
Type 1	Type 2	Type 1	Type 2			
3	0	3	3	95.0	830.0	960.8
3	0	3	3	95.0	840.0	968.6
3	0	3	3	95.0	850.0	976.7
3	0	3	3	95.0	860.0	984.9
3	0	3	3	95.0	870.0	993.0
3	0	3	3	95.0	880.0	1001.3
3	0	3	3	95.0	890.0	1009.6
3	0	3	3	95.0	900.0	1017.9
3	0	3	3	95.0	910.0	1026.3
3	0	3	3	95.0	920.0	1034.8
3	0	3	3	95.0	930.0	1043.4
3	0	3	3	95.0	940.0	1051.8
3	0	3	3	95.0	950.0	1060.3
3	0	3	3	100.0	670.0	902.0
3	0	3	3	100.0	670.0	972.0
3	0	3	3	100.0	680.0	896.2
3	0	3	3	100.0	680.0	1002.8
3	0	3	3	100.0	690.0	895.2
3	0	3	3	100.0	690.0	1031.4
3	0	3	3	100.0	700.0	898.2
3	0	3	3	100.0	700.0	1057.8
3	0	3	3	100.0	710.0	901.0
3	0	3	3	100.0	710.0	1083.0
3	0	3	3	100.0	720.0	905.1
3	0	3	3	100.0	720.0	1107.2

Fig. 3. Reciprocating Compressor Performance Calculations Output from "Capacity" Phase — Compression Unit "X"

Head end pockets open		Crank end pockets open		Compressor capacity MMcf/day	Suction pressure psi	Discharge pressure psi
Type 1	Type 2	Type 1	Type 2			
3	0	3	3	210.0	870.0	1068.2
3	0	3	3	210.0	880.0	1088.2
3	0	3	3	210.0	890.0	1108.1
3	0	3	3	210.0	900.0	1128.0
3	0	3	3	220.0	680.0	665.9
3	0	3	3	220.0	690.0	685.4
3	0	3	3	220.0	700.0	705.0
3	0	3	3	220.0	710.0	724.6
3	0	3	3	220.0	720.0	744.2
3	0	3	3	220.0	730.0	763.9
3	0	3	3	220.0	740.0	783.5
3	0	3	3	220.0	750.0	803.2
3	0	3	3	220.0	760.0	823.0
3	0	3	3	220.0	770.0	842.7
3	0	3	3	220.0	780.0	862.5
3	0	3	3	220.0	790.0	882.2
3	0	3	3	220.0	800.0	902.0
3	0	3	3	220.0	810.0	921.8
3	0	3	3	220.0	820.0	941.7
3	0	3	3	220.0	830.0	961.5
3	0	3	3	220.0	840.0	981.4
3	0	3	3	220.0	850.0	1001.2
3	0	3	3	220.0	860.0	1021.1
3	0	3	3	220.0	870.0	1041.0
3	0	3	3	220.0	880.0	1061.0

The required data are punched into cards according to a prescribed format for entry into the computer.

The computer calculates the compressor performance in two phases. In the first phase the discharge pressure is calculated as a function of the suction pressure and the engine load. Discharge pressures are calculated between specified upper and lower limits of discharge pressure. Calculations are carried out for specified increments of suction pressure and engine load between upper and lower limits of these variables for each desired pocket condition. This phase is referred to below as the LOAD phase.

In the second phase the compressor discharge pressure is calculated as a function of suction pressure and compressor capacity, or throughput, at the desired pocket conditions. The calculations are carried out for specified increments of suction pressure and capacity between specified upper and lower limits of these variables. This phase will be referred to as the CAPACITY phase.

In each phase the results are punched on cards from the computer and printed reports are prepared from the punched cards. Fig. 1 is a work flow diagram illustrating the data processing procedure for this application.

Fig. 2 and 3 show the format of the printed reports prepared from the results of computation. Fig. 2 shows results from the LOAD phase and Fig. 3 shows results from the CAPACITY phase.

For the use of the operating personnel it has been found desirable to produce a plotted curve of the results of the compressor performance calculations showing the results of both computational phases on one sheet. Fig. 4 illustrates a typical operating curve prepared from computed results.

Details and Method of Calculation

Load Phase:

Calculation of discharge pressure as a function of suction pressure and engine load involves an iterative type solution because discharge pressure is not directly defined in terms of these variables.

The compressor cylinder displacement volumes are calculated by:

$$(DV)_{HE} = \frac{\pi D^2 S}{4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$(DV)_{CE} = \frac{\pi (D^2 - d^2) S}{4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$DV = (DV)_{HE} + (DV)_{CE} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Where:

$(DV)_{HE}$ = Head-end displacement volume, cu in.
$(DV)_{CE}$ = Crank-end displacement volume, cu in.
DV = Cylinder displacement volume, cu in.
D = Cylinder bore diameter, in.
d = Rod diameter, in.
S = Length of stroke, in.

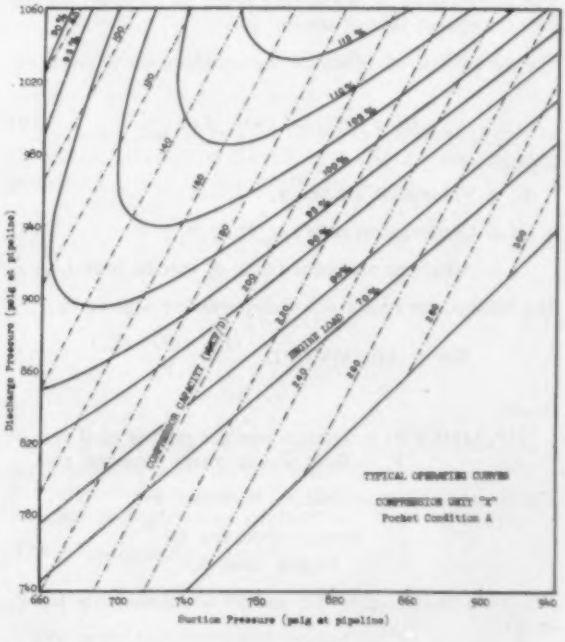


FIG. 4.

The daily piston displacement for the compressor is calculated by:

$$PD = (DV) \times \frac{(1440)\ (N)\ (RPM)}{1728 \times 10^6} \quad . \quad . \quad (4)$$

Where:

PD = Piston displacement, MM cu ft per day
N = Number of compressor cylinders
RPM = Engine speed, RPM

The fixed clearance volume is calculated by:

$$CV_o = N\ [(Cl)_{HE} \times (DV)_{HE} + (Cl)_{CE} \times (DV)_{CE}] \quad (5)$$

Where:

CV_o = Fixed clearance volume, cu in.
$(Cl)_{HE}$ = Fixed clearance of head end, fraction.
$(Cl)_{CE}$ = Fixed clearance of crank end, fraction.

The effective pocket volume is calculated as the sum of the volumes of the pockets open. The effective clearance is then calculated by:

$$C = \frac{CV_o + VP}{DV \times N} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Where:

C = Clearance, fraction
VP = Volume of pockets open, cu in.

Adjustments for piping losses are made by:

$$P_1 = P_s - 5 \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$P_2 = P_D + 3 \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Where:

P_1 = Inlet pressure at compressor cylinder, psia
P_s = Suction pressure at measuring point on pipeline, psia
P_2 = Discharge pressure at compressor cylinder, psia
P_D = Pressure at measuring point on pipeline on discharge side of station, psia

The volumetric efficiency of the compression is given by:

$$E_v = 0.97 - C\ (R^{\frac{1}{n}} - 1) \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Where:

E_v = Volumetric efficiency, fraction
R = Compression ratio = $\frac{P_2}{P_1}$
n = Adiabatic exponent (ratio of specific heats)

The horsepower required for compression is given by:

$$HP = (HP/MMCFD)\ \frac{(P_1)\ (PD)\ (E_v)}{P_o} \quad . \quad (10)$$

Where:

(HP/MMCFD) = Horsepower per million cu ft per day
P_o = Base measurement pressure, psia

The fractional engine load, L, is defined by:

$$L = \frac{\text{Engine operating hp}}{\text{Engine rated hp}} \quad . \quad . \quad . \quad . \quad (11)$$

Solving Equations 9, 10, and 11 simultaneously for P_2, we get:

$$P_2 = P_1 \times (Y + 1)^n \quad . \quad . \quad . \quad . \quad (12)$$

Where:

$$Y = \frac{0.97 - \frac{L}{B}}{C} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Where:

$$B = \frac{(HP/MMCFD)\ (P_1)\ (PD)}{(P_o)\ (HP)\ \text{rated}} \quad . \quad . \quad (14)$$

The first difficulty in attempts to solve for P_2 directly is due to the fact that the horsepower per million cubic feet per day is a function of the compression ratio (hence, a function of P_2). The other difficulty is that, in general, P_2 is not a single valued function of load and inlet pressure.

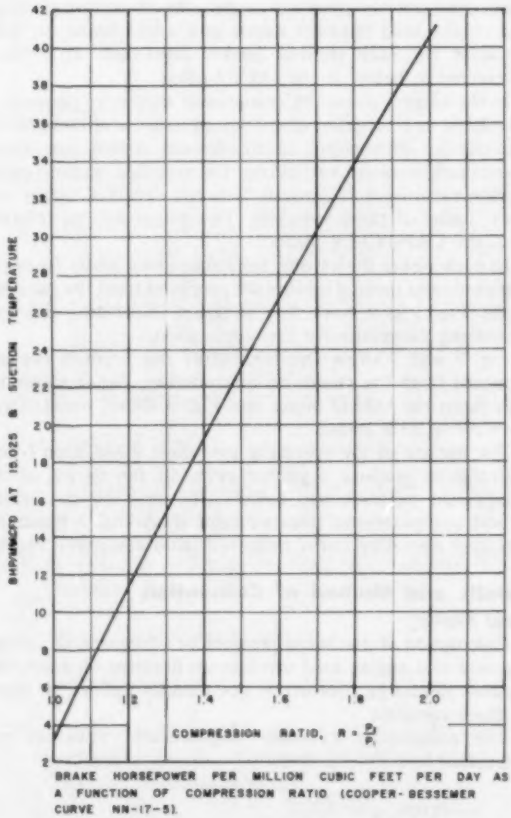
Fig. 5 shows the variation of brake horsepower per million cubic feet per day as a function of compression ratio. A least-squares fit of this curve was obtained to relate the factor horsepower per million cubic feet per day to the compression ratio "R" in equation form for use by the 650. The fit obtained was:

$$HP/MMCFD = A_o + A_1R + A_2R^2 + A_3R^3 \quad . \quad (15)$$

Where:

A_o = –46.361993
A_1 = 57.010116
A_2 = 8.5786555
A_3 = 0.91439689

In order to solve for P_2 at given values of P_1 and L, a function, $f(P_2)$, was set up and solved, by trial and error,



BRAKE HORSEPOWER PER MILLION CUBIC FEET PER DAY AS A FUNCTION OF COMPRESSION RATIO (COOPER-BESSEMER CURVE NN-(7-5).

FIG. 5.

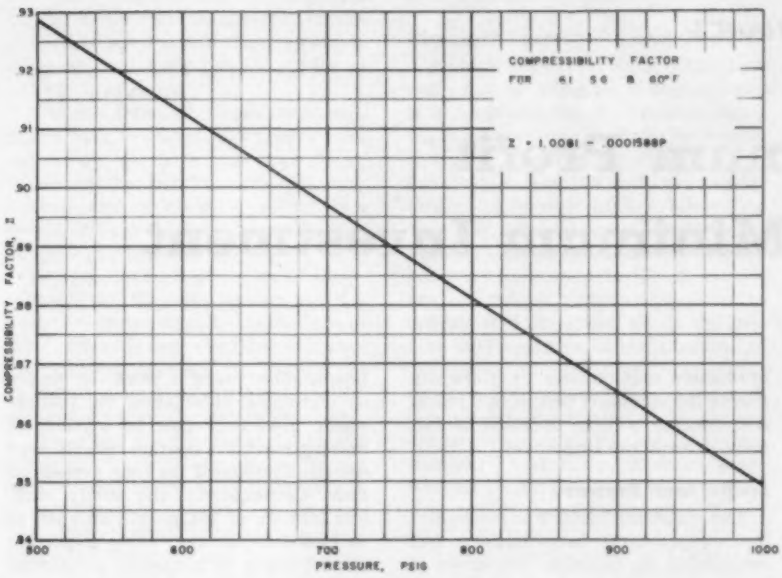


FIG. 6.

R. L. Ridings *has been with Texas Eastern Transmission Corporation since August, 1958, and is a senior programmer in the company's methods and systems section. In this capacity, he has prepared gas availability and deliverability programs for electronic computer applications as well as doing work on a number of other programs.*

Ridings served three years in the U. S. Air Force and attended Texas A&M College where he received a bachelor's degree in petroleum engineering in 1957 and a master's degree in petroleum engineering and mathematics in 1958.

Currently, he is a member of the Society of Petroleum Engineers, the Society for Industrial and Applied Mathematics, the Association for Computing Machinery and the Texas Society of Professional Engineers.

by successive improvements on an assumed value of P_2. This function may be expressed as:

$$f(P_2) = P_1 \times (Y + 1)^n - P_2 \quad . \quad . \quad . \quad (16)$$

where the term Y is defined by Equations 13 and 14, above.

To solve for the zeros of the function $f(P_2)$, the values of the function were examined over intervals of P_2. A sign change in the function in the interval $[(P_2)_n, (P_2)_{n-1}]$ is determined if

$$[f(P_2)_n - f(P_2)_{n-1}] > [[f(P_2)_n] - [f(P_2)_{n-1}]] \quad . \quad (17)$$

When a sign change in the function within an interval is detected, convergence is achieved by successive improvements on P_2 by interpolating on the slope of the function using Newton's method. The solution for $(P_2)_{n+1}$ is obtained by:

$$(P_2)_{n+1} = (P_2)_n - \frac{f(P_2)_n}{f'(P_2)_n} \quad . \quad . \quad . \quad (18)$$

Where:

$f'(P_2)_n$ is approximated by

$$f'(P_2)_n = \frac{f(P_2)_n - f(P_2)_{n-1}}{(P_2)_n - (P_2)_{n-1}} \quad . \quad . \quad . \quad (19)$$

To reduce the calculation time required for the term $(Y + 1)^n$, a 5th degree polynomial approximation was obtained in the form of:

$$(Y + 1)^n = \sum_{i=0}^{5} a_i Y^i \quad . \quad . \quad . \quad (20)$$

for $0 \leqslant (Y + 1) \leqslant 3$.

Capacity Phase:

Calculation of compressor discharge pressure as a function of suction pressure and compressor capacity is straightforward since the discharge pressure may be expressed as a single-valued function of suction pressure and capacity.

Compressor capacity is expressed by:

$$Q = \frac{(PD)(E_v)(P_1)(T_o)}{(P_o)(T_1)(Z_1)} \quad . \quad . \quad . \quad (21)$$

Where:

Q = Compressor capacity, volume/time.

T_o = Base temperature, deg R = (deg F + 459.63)

T_1 = Inlet temperature, deg R

Z_1 = Gas deviation factor at inlet conditions

All other items are defined above.

Assuming that $T_o = T_1 = 60$ F, and combining the relationships involved in Equations 9 and 20, the discharge pressure P_2, may be expressed as:

$$P_2 = P_1 \times (Y + 1)^n \quad . \quad . \quad . \quad . \quad (22)$$

Where:

$$Y = \frac{0.97 - A}{C} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

$$A = \frac{(Q)(Z_1)(15.025)}{(PD)(P_1)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

Fig. 6 shows the curve used for the gas deviation or compressibility factor as a function of pressure. A straight-line approximation is used for the gas deviation factor in the interval of pressures involved.

The approximation used is:

$$Z(P_1) = 1.0081 - 0.0001588\ P_1 \quad . \quad . \quad . \quad (25)$$

The same approximation is used for $(Y + 1)^n$ as described above for the LOAD phase. ★ ★ ★

Maximum Profit with Minimum Investment

Alva C. Smith
Senior Mechanical Engineer
Mid-Continent Pipe Line Company

IN THIS AGE OF IDEAS, planned maintenance has emerged as one of industry's most prized profit-producing functions. Competition has necessitated more productive maintenance to meet the demands of an increasingly complex and rapidly changing civilization. Industry in general, and the pipeline industry in particular, has responded to this challenge with enviable records of achievement.

Our primary interest in this article is to focus on some of the most productive maintenance developments of the past 20 years, and the most promising trends of the future. Emphasis will be placed upon the profitability of productive maintenance with a minimum of investment. Consequently, it would be difficult to overemphasize the fact that maintenance dollars saved are gross profit dollars made.

Practical maintenance will be stressed rather than abstract science, because productive maintenance is doing what can be done with science today. For example, a reliable and authoritative report received by the writer indicates a new development in wheel lubrication has virtually eliminated a company's wheel bearing trouble, with annual savings amounting to $25,000. A second report relates how a large taxi company reduced its operating cost from 3.12 cents to 1.3 cents per mile, saving $1000 per car per year.

Well planned and executed maintenance can duplicate these results in your business, be it large or small. A productive maintenance program can reduce the operating cost of any industrial concern without excessive investment in tools and equipment.

Scope and Purpose

The era of the "shade tree mechanic" has passed and maintenance has emerged as big business. The scope of the business can be appreciated when it is realized the maintenance cost of our Pacific Coast industries alone will exceed $3 billion in 1960.

The aim of this article is quite positive — it is to give each operator seriously intent upon reducing operating cost confidence that he can and should have a productive maintenance program. A further purpose is to answer the who-what-how-when-where type of questions related to your maintenance program. These answers will be confirmed by quantifying examples, taken from actual records.

Basic Facts and Relations

The testimony of industrial history and hindsight have proved that breakdown repair maintenance is an expensive luxury that the profit-minded organization can no longer afford. In a mechanized competitive society, there is no such thing as no maintenance program. Every industrial concern has one — good or bad. It is profitable to realize that all economic laws are controlled by unchangeable physical laws. Appreciation of these basic facts and relations is a positive step toward productive maintenance.

The old misconception that only "hammer and pry mechanics" should be concerned with maintenance only caused management to sign bigger maintenance checks. In brief, you have a maintenance program irrespective of whether it be by plan or by default. Operators may discover that attention to seemingly "small matters" is a surefire method of increasing profits.

Human Factors

The alert operator will never forget that however marvelous the machine, people must make it work. In an era of increasing automation the maintenance mechanic must be capable of making machines operate reliably even though unattended for long periods of time. Consequently, the ability, skill, and attitude of the people assigned to maintenance is the most important consideration in achieving productive maintenance. Select men with a wide background of mechanical training and experience, calm disposition, inquiring mind, and a sincere interest in maintenance as such.

Productive maintenance begins with the selection of a maintenance supervisor or master mechanic, depending upon the amount and complexity of equipment to be maintained. He should work directly under management that is charged with proprietary responsibility. His decisions, for example, to take a piece of equipment out of service should be subject to their veto alone. The enormous sums expended for maintenance automatically involves those who are entrusted with full-profit responsibility. This supervisory-management team must be aware that nearly all efficiency has to do with anticipation of need; anticipation of where to set your "maintenance foot" in the next step forward.

The journey to productive maintenance begins with the first step—seeing that your maintenance program is planned and has the required fundamentals. The five fundamentals are (1) productive employees, (2) adequate records, (3) job inspection, (4) communications, and (5) equipment and procedure standards. We must never forget that productive maintenance is gathering the right fundamentals and then doing something about them. Ideas alone are not enough. Action must follow consistently.

Experienced maintenance men have probed the maintenance problems of hundreds of companies, large and small. The result has been widespread agreement that cost reduction efforts are most successful in those companies that consistently and methodically con-

duct a planned maintenance program. The "blow hot and cold" maintenance approach in which cost cuts are ordered every few months and then interest is lost after each order is issued are found to be least effective.

The one thing all maintenance programs have in common is people — as individuals or in groups. Experience has shown that fair, firm, friendly, considerate and cooperative dealing with people will do much to increase a flow of ideas and increase output.

The present and the future of maintenance, as in other phases of the industry, starts and grows in the human mind. There is overwhelming evidence that creative thinking, viz, putting the imagination to work effectively, is the cornerstone of productive maintenance.

The more competitive industry becomes the more important productive maintenance looms. The right answer to maintenance questions is also the right answer to profit questions as heretofore has been stressed by examples. The trend toward mass productive maintenance can be accelerated by realization that creative thinking, and especially plain ordinary idea production, is possible and desirable for the average person. It follows that a flow of ideas and sincere interest in the job go hand in hand with productive maintenance. The result will be an effective approach to the maintenance problem rather than mere hit and miss repair methods formerly used.

Physical Factors — and Profits

Natural laws control economic laws and must be respected if maintenance is to be productive. In practical maintenance these laws result in such commonplace functions as follows:

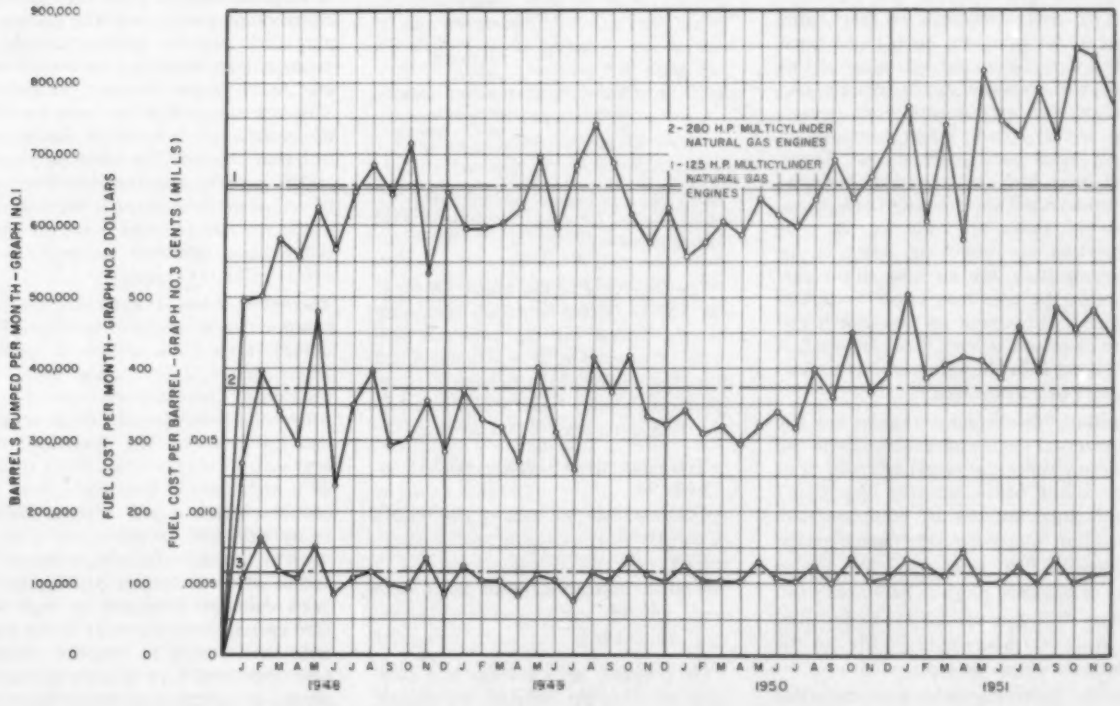
Lubrication. The low cost operation of machinery depends more on lubrication than any other factor. Lubrication in practice means reduction of friction and wear to prolong the life of machinery and reduce the power required to operate it. Lubrication of all the rubbing surfaces permits the machine to work; good lubrication practices always result in reduced operating expense. It is absolutely essential that all machinery receive proper and continuous lubrication. These basic principles apply whether the motion is rolling or sliding; they apply, therefore to all ball and roller bearings.

Recent developments in lubrication practices have been numerous; however, the development of the automatic oil-level controller has removed the most stubborn barrier to unattended operation of internal-combustion engines for long periods of time. There are numerous devices for automatic oil-level control, which insure a continuous supply of oil to the crankcase and maintain a constant oil level. The writer has selected automatic oil level control to emphasize the profitability of productive maintenance with small capital investments.

Numerous tests by Mid-Continent Pipe Line Company, on many engines, proves the automatic oil-level controller to be highly reliable. The installed costs of the average automatic oil-level controller is approximately $60 per unit. It will consistently reduce crankcase oil consumption 50 to 55 percent — which amounts to 30 cents per day or $100 a year, for a 100-hp multi-cylinder gas engine in continuous full load service. Thus, the rate of gross return on investment is 165 percent.

Proper lube oil filtration practice likewise demonstrates the profitability of productive maintenance. Given an oil that will correctly lubricate when new, it is then necessary to continuously purify it to ensure complete and continuous lubrication. Filtration is required because a lubricant picks up dirt, carbon, water, etc. Some of the oil oxidizes or "rusts" and some of the more unstable or weaker molecules break down under the high temperature and pressure.

Adequate filtration equipment installed on 15 to 300-hp multi-cylinder natural gas engines will return the investment, in lube oil savings alone, in 7000 to 7700 hours of engine operation. A repetitive savings of equal



Graphic fuel cost record for natural gas engines in crude oil pipeline service.

amount will be returned thereafter during the service life of the engine. On a 100-hp engine this saving amounts to 50 cents per day or $180 per year. Thus, the payout period is approximately 10 months and the rate of return on the investment is 110 percent.

Oil bath air cleaners. The writer recently visited oil leases where the pumpers had been instructed to remove oil bath air cleaners from their engines. Failure to install and properly maintain air cleaners is a sure-fire way to engine troubles and expensive repairs. An efficient air cleaner for both the carburetor and the crankcase breather is essential to trouble-free service and long engine life. Engine manufacturers regard improperly maintained air cleaners as grounds for voiding their guarantee.

It would be difficult to overemphasize the importance of eliminating air borne dirt from engine air ducts. Extensive tests have proved conclusively that only 8.3 ounces of dust is sufficient to wear out an 80-hp engine in 50 hours of operation. Thus, less than a half-thimble full can heavily damage an engine valued in excess of $4000. The extent of that damage can be expected to range from $700 to $1000. It does not matter how long it takes to put the dust through the cylinders. Whether it takes 100 hours or 10,000 hours, when this much abrasive has passed through the engine, it is worn badly enough to cause spark plug fouling due to high oil consumption.

The dust concentration per cubic foot of air does not have to be great when it is considered an engine of this type will consume approximately 24,000 cu ft of air per hour when operating at full speed. When operating in dusty areas such as Oklahoma, Texas, and New Mexico, it is good business to understand the function and operation of these air cleaners. If your operators are punching holes in, or disconnecting, the air hose to the carburetor the cost may come high. Obviously, the payout on investment and rate of return is very high; however, it is more difficult to measure in exact dollars or percentages.

Ignition. Most engine troubles are due to external engine accessories, with the ignition being the worst offender. For this reason Mid-Continent Pipe Line's natural gas engines are equipped with platinum electrode type spark plugs. Extensive field tests show the service life of standard plugs to be 900 to 1100 hours of engine operation as compared with 22,000 hours average life for the platinum electrode type.

The following data were recorded by the writer after inspecting 18 platinum electrode spark plugs that had been in heavy duty service 51 months prior to removal for inspection:

*Engine No.	No. cyls.	Fuel	**Actual hr of operation	Remarks
Unit 1	6	Nat. Gas.	19,084	Excellent condition—returned to engine for further service.
Unit 2	6	Nat. Gas.	26,868	Excellent—showed signs of white deposits on electrodes—cleaned and returned to service.
Unit 3	6	Nat. Gas.	20,917	Excellent condition—removed whitish deposits—returned to service.

*85-hp natural gas engines—(multi-cylinder).

**Average life per set of plugs—22,434 hours at the date of inspection.

The total cost of the above 18 plugs was $67.14. From accurate operating records, based on the previous five years of operation, it was determined that plug cost would have been $514.08 (plug cost alone) had we continued to use standard plugs. Total savings:

Total savings $(514.08 - 67.14) = \$446.94$

Total savings per engine per month $= \frac{446.94}{3 \times 51} = \$2.92$

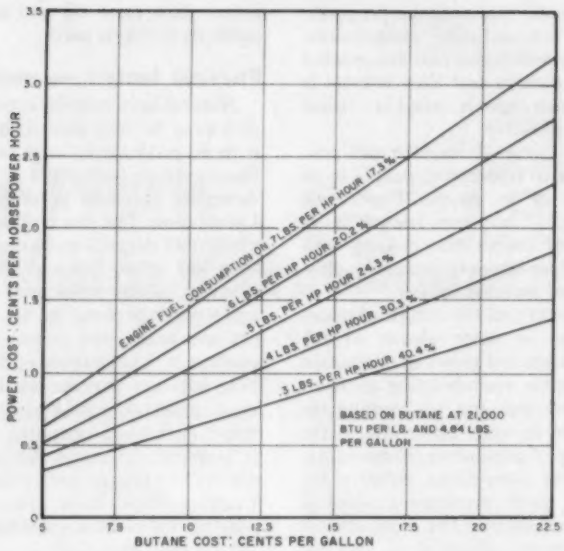
Unit savings per cylinder per month $= \frac{446.94}{51 \times 18} = \$0.487$

On previous tests savings had averaged 46 cents per cylinder per month, thus the above test confirms previous information and trends, developed over more than four years of testing. The payout period on these platinum plugs was 8½ months, and the rate of investment was 130 percent.

The reader should not overlook the repeat savings involved in this kind of maintenance. An equal amount was returned to the operator each succeeding 8½ months during plug service life.

Subsequent experience and cost records indicated a noticeable decrease in magneto repairs when the platinum electrode plug was used. The savings in plug cost, plus the indirect savings in magneto cost, increased the overall savings to $1.55 per cylinder per month. This amounts to $110 per year for 100-hp natural gas engine in continuous full load service. The ultimate payout is 2½ months and the repetitive rate of return on investment is 500 percent. Later records indicate some of these plugs have operated successfully in excess of 28,000 hours.

Magnetos. Most oilfield engines are equipped with magneto ignition. This device serves as a source of ignition where dependability is the first consideration. There are two types of magnetos commonly used: High tension and low tension. The operation of a low tension magneto is similar to that of a high tension magneto except the output current is low voltage. Before being delivered to the spark plug, it must be transformed to high voltage by means of an induction coil located at each cylinder. Removal of high tension current from the body of the magneto itself results in long-life trouble-free operation. Low tension ignition is especially desirable on larger multi-cylinder engines in the 100-hp class and upward. The following information of



Butane fuel cost for spark ignition engines.

record will best demonstrate the advantages of low tension.

Our company converted a 6-cylinder used magneto to low tension at a cost of approximately $120. This magneto was then installed on a 280-hp natural gas engine and operated 27 months (or 16,395 actual hours) prior to removal for shop repairs. A thorough inspection of the magneto at the end of this period indicated only mechanical wear was detectable, such as magneto coupling, impulse coupling, etc. None of the electrical components required replacement. The unit repair cost was 96 cents per month as compared with $2.50 per month for the average high tension magneto. Direct magneto shop repair cost was reduced 62 percent.

Prior records had shown 5000 hours to be the average interval between shop repairs for high tension magnetos. The overall savings was $3.20 per month (including company labor). The payout period was 38 months and rate of return on additional investment was 32 percent. Similar results have since been duplicated on a number of similar applications.

Engine overhaul. Productive maintenance can return extraordinary savings on engine operation and overhaul. The profits are derived from materially extending the periods between overhauls and reducing the overhaul cost when overhaul becomes necessary.

In 1945 engine manufacturers recommended overhaul of multi-cylinder gas engines at 7500 hour intervals, (operating hours). Today, these same engines are being successfully operated 30,000 to 55,000 hours between overhauls. The following examples demonstrate these savings are possible with small unattended field pumping engines as well as the larger attended or unattended engines at pump stations and elsewhere:

Description	Hp	Cu in. displacement	Hours between overhaul	Total overhaul cost	Overhaul cost per hp per year
4 cyl. Nat. Gas	16	123	37,600	$ 00	$0.61
6 cyl. Nat. Gas	125	1280	55,188	$1,422	$1.80
6 cyl. Nat. Gas	280	2894	48,420	$1,780	$1.15

This kind of performance and cost control can be and is being accomplished on a wide scale. Any productive maintenance program can duplicate or even surpass these results. During the period the above tabulated data was being recorded, our company had five engines running well above 30,000 hours since overhaul. Eleven other engines were operating in the 15,000 to 25,000 hour range; all of which continued to operate satisfactorily.

Long term records of 11 280-hp (2894 cu in.) engines, prior to 1953, indicate the average interval between overhauls was 15,000 operating hours. Average overhaul cost of these same engines was $1325 per engine. Consequently, the overhaul cost has been reduced 58 percent by productive maintenance techniques, some of which have been described previously. Specifically, the saving is $450 per engine per year, or $37.50 per month.

Obviously, this type of savings can materially increase the gross profits of an operator with several or many engines — aside from reducing downtime loss, etc. Patronizing reliable overhaul shops will materially reduce overall cost. Runs between overhauls, on the above-described engines, increased 78 percent soon after they were shopped for major overhauls.

Hardsurfacing parts. Maintenance cost can be reduced materially by hardsurfacing reclaimed or used parts. Each method has some physical and economic advantages and disadvantages.

Metallizing will extend materially the service life of wearing parts, however, it is more expensive than hard chrome plating. Many expensive machine parts can be reclaimed by metallizing at a fraction of their replacement cost. The metal bond of metallizing is less effective than chrome plating. The cost of chrome plating large pump piston rods is 41 to 47 percent less than metallizing. Cost of chrome plating usually ranges from 60 to 80 percent of new-parts cost. The service life of the chrome parts is usually doubled or tripled. Thus, the cost of operating chrome plate rods is approximately 23 percent that of standard rods.

Chrome plating engine crankshafts permits journals to be kept standard size, thereby eliminating undersize bearings. The cost of chrome plating a crankshaft ranges from 50 to 70 percent of new shaft prices, for most multi-cylinder pipeline engines. The larger the engine, the greater the savings. Service life of chrome plated shafts is three to five times that of non-hardened shafts. On a 280-hp engine the return on cost of chrome plating is approximately 20 percent; the indirect savings in bearings and overhaul cost are indeterminate, but are known to be much greater.

Chrome plated cylinder liners, inspected after 9012 hours of service in a 125-hp multi-cylinder gas engine showed less than 0.001 in. of wear. The cost of porous chrome plating these liners was 72 percent that of new liner cost. The service life of these liners may be expected to exceed that of standard cast-iron liners by three times. The rate of return is approximately 15 percent plus greater indirect savings in piston rings, etc.

Flame hardening is a process in which thin coatings of tungsten carbide and aluminum oxide are applied by fusion. This process is most desirable and successful where wear is extremely critical. It will insure maintenance of the original clearances for long periods of time. Records indicate flame hardened pump piston rods have an average service life of 14,250 hours, which is approximately 2½ times that of standard rods. However, the cost of flame hardened rods is approximately three times that of standard rods and the rate of return was not considered favorable in this application. The relative low average life was due to rod breakage rather than abrasive wear.

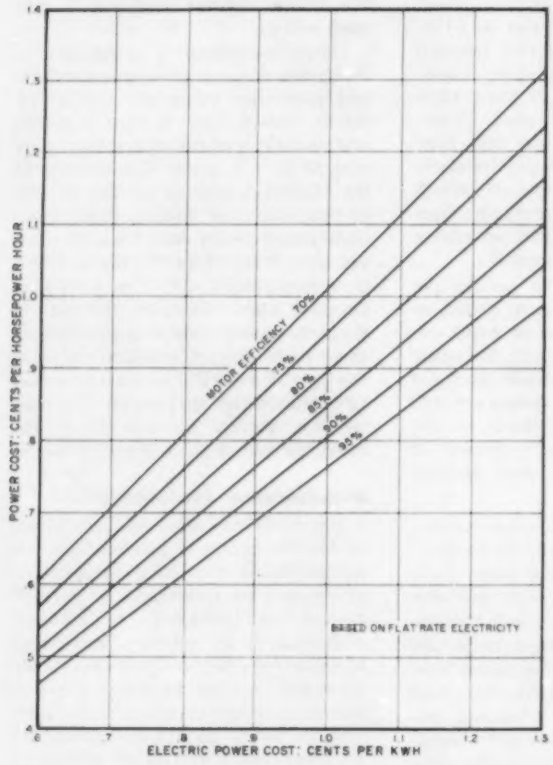
Maintenance Evaluation

Emphasis heretofore has been placed on specific phases of maintenance, and the profitability of each measured in rate return on investment or percentage of cost reduction. Maintenance evaluation is of primary importance because it is a follow-up of overall performance and the potential worth of the maintenance program. It evaluates what is being paid for — productive maintenance. This kind of evaluation involves maintenance manpower, equipment, methods, and individual machines or groups of machines, in relation to a company's primary objective — profitability. The following examples and tabulated data will best illustrate this function.

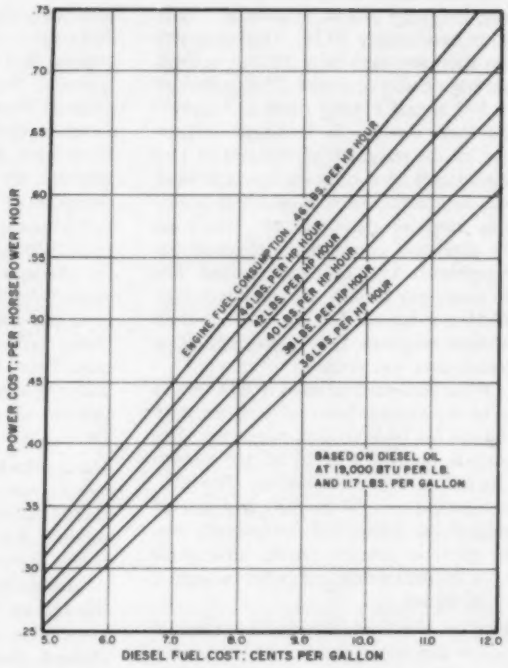
In a preceding paragraph a 280-hp multi-cylinder gas engine was described as being operated 48,420 hours between overhauls. This engine drives a reciprocating pump delivering 12,500 bbl per day at 850 psi. During the interval of operation, engine performance can be summarized as:

Total power produced (240 x 48,420)	11,620,800	hp-hr
Total gas consumed (@11 cu ft per hp-hr)	127,829	Mcf
Total cost gas consumed (@$0.20 Mcf)	$25,565	
Total equivalent electric power	8,672,238	kwhr
Total equivalent cost electric power (@$0.011 (11 mils) per kwhr)	$95,395	
Net difference in fuel cost ($95,395—$25,565) =	$69,830	
Less lube oil cost	$1,600	
Less overhaul cost @ end of 42,408 hr	$1,780	
Less routine engine maintenance between overhauls	$2,100	
Net savings during 42,408 hr operation	$64,350	
Net savings per hr operation	$1.52	
Net savings per hp-hr	$0.00554	(5.5 mils)

The above data demonstrate relative gross operating cost based on actual comparative fuel cost. This same en-



♦ Electric power cost for induction motors.


POWER COST: PER HORSEPOWER HOUR
ENGINE FUEL CONSUMPTION .46 LBS. PER HP HOUR
.44 LBS. PER HP HOUR
.42 LBS. PER HP HOUR
.40 LBS. PER HP HOUR
.38 LBS. PER HP HOUR
.36 LBS. PER HP HOUR
BASED ON DIESEL OIL AT 19,000 BTU PER LB. AND 11.7 LBS. PER GALLON
DIESEL FUEL COST: CENTS PER GALLON

Diesel engine fuel cost.

gine operating on 30-cent gas would have shown a net savings of $43,000 during this 42,408 hour interval, or a saving of $0.0037 (approximately 4 mils) per hp-hr.

The 11-mils rate ($0.011) for electrical energy is near the minimum for installations of 1000 hp and less. This cost determination will be demonstrated in the following tabulated data. These data summarize nine years of operation — 650-hp electric pump station — in a middlewest area where the comparative gas rates* used here are relatively high.

1. Total electric energy consumed, kwhr	14,987,366
2. Total electric energy cost	$164,795.24
3. Avg. cost per kwhr consumed	$0.0109956 (11 mils)
4. Total equivalent hp-hr consumed	20,082,084
5. Total equivalent gas consumed, Mcf	217,677
6. Total equivalent cost gas consumed	$69,113.92
7. Avg. cost gas consumption per Mcf	$0.3175
8. Avg. cost gas consumption on a per kwhr basis	$0.004611
9. Potential fuel savings per kwhr consumed	$0.006384
10. Fuel cost ratio—electricity to gas	2.385:1.000
11. Indicated potential fuel saving	$95,681.32
12. Indicated potential fuel saving, %	58.06

The above data summarize the fuel cost record since electrification. The original station was increased from 150 to 300 hp over a period of 51 months. It was then enlarged to 650 hp and has operated 57 months at the later installed horsepower (exclusive tank boosters, etc.). Increasing the installed horsepower 115 percent reduced the potential fuel savings from 58.06 percent to 55.65 percent. Thus a 100 percent increase in installed horsepower reduced overall power cost 2.1 percent. The reduction in overall power cost due to graduated rate schedules and increased load is emphasized.

As a major operating cost, energy or fuel consumption is of primary importance to the use of a continuous service prime mover. Naturally, fuel cost should be closely scrutinized by the effective operator. Generally, natural gas, LPG, crude oil, or diesel oil provide a premium fuel at less cost than gasoline or electricity, in most areas. It is most important, however, to understand that total cost of operation is not necessarily proportionate to fuel cost. An honest evaluation of ultimate cost must recognize that electrical units may operate with only limited attention, aside from motor failures. Contrary to many people's ideas, the same is true of modern engines. From accurate records it has been determined that the maintenance cost ratio of gas engines, as compared to electric motors, is approximately 2.50:1.00. An effective maintenance program can reduce this cost ratio to 2.00:1.00.

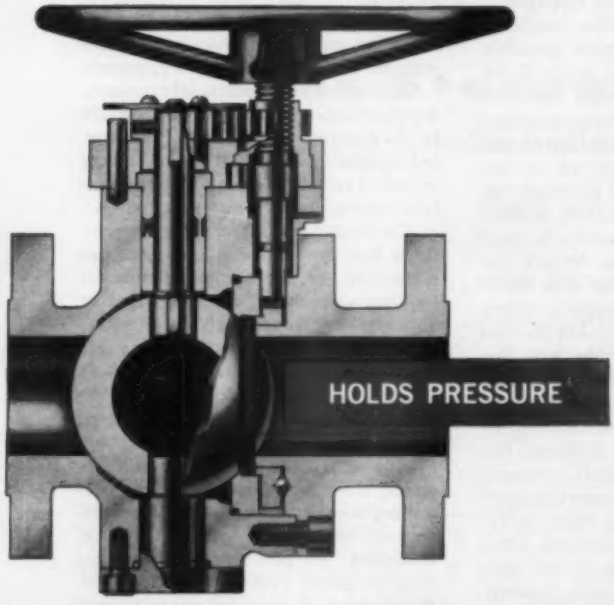
The overall effect of fuel and maintenance cost on the above described 650-hp pump station for the past 57 months of operation can be determined as:

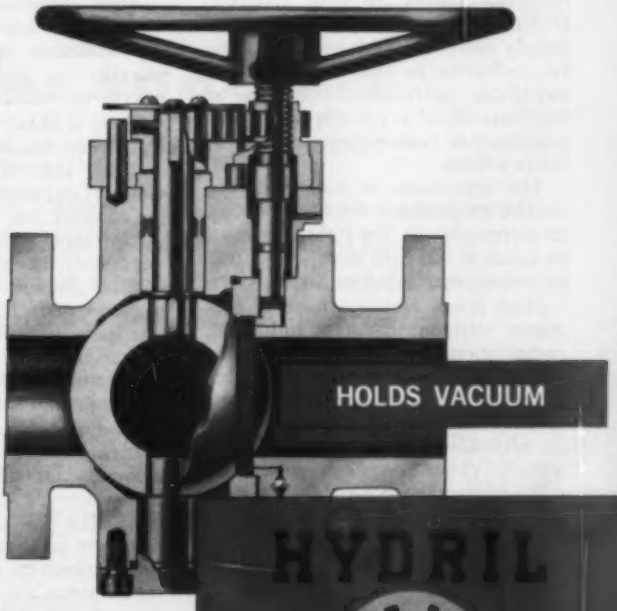
A. Annual gross fuel savings: 2,990,000 x 0.006384 =	$19,100
1. Less 6% for lights, auxiliaries, etc.	1,150
2. Annual net fuel savings	17,950
B. Comparative maintenance cost:	
1. Annual maintenance cost—650 installed hp gas engines @ $8.00 per hp/year—650 x 8 =	$5,200
2. Annual maintenance cost—650 installed hp electric motors @ $3.00 hp/year 650 x 3 =	1,950
3. Annual increase in maintenance cost w/gas engines (5200-1950) =	3,250
C. Net annual savings with natural gas prime movers:	
Annual net fuel savings	$17,950
Less annual increase in maintenance cost	3,250
Annual gross savings (before taxes)	14,700
Annual net savings (after taxes) (14,700 x .43)	6,320
D. Annual net savings per installed hp 6,320 + 650 = $9.73 per hp/year, say	$10

In the above analysis, operating manpower requirements were identical, irrespective of type of prime movers used. The maintenance cost ratio was

Exclusive Controlled Compressible Port Seal

provides fast, positive shutoff in any service...





Controlled sealing . . . a new concept in valve design . . . is the secret of Hydril's tight, bubble-proof shutoff. Hydril Ball-Plug Valves always seal positively against pressure from either direction—or against vacuum—because the fully confined packing ring is mechanically compressed between plug and seat when the valve is closed. This tightly compressed gasket type seal easily bridges clearances between parts as well as surface imperfections. Result: seal efficiency is unimpaired by prolonged hard usage, by rust or sediment.

Design of Hydril Type "K" Ball Plug Valves assures minimum maintenance costs. Non-lubricated, they employ no sealing lubricants. There's no sliding friction between plug and body to produce wear and abrasion.

The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

Hydril valves are available in a wide range of sizes and ratings. Worm-gear and motor-operated models can be supplied. Get the full story on Hydril Valves from your nearby representative . . . or write Hydril Company for free Catalog No. V-60.

HYDRIL

BALL Type "K" PLUG

VALVES

HYDRIL COMPANY

714 West Olympic Boulevard, Los Angeles 15, Calif.

Factories at: Los Angeles; Houston, Texas; Rochester, Pa.

Sales Offices: California: Bakersfield, Los Angeles, Ventura • **Louisiana:** Harvey, New Iberia, Shreveport **Oklahoma:** Oklahoma City, Tulsa • **Texas:** Corpus Christi, Dallas, Houston, Midland, Odessa • **Wyoming:** Casper **New York:** New York • **Canada:** Calgary, Edmonton

2.500:1.00. Thus, on the basis of 11-mil current, compared with 32-cent Mcf gas, a net saving of $10 per hp per year was realized. Productive maintenance can reduce this ratio to 2.00:1.00 and increase savings to $10.60 per hp per year — a 6 percent increase in net profit dollars.

The foundation of maintenance evaluation is good records. Unless pertinent details of performance, inspection, maintenance, and repair are made a matter of record, you will not have a productive maintenance program. Records should be complete but as simple as possible. All records must be kept conscientiously and used consistently if maximum results are to be obtained. Ordinary accounting records are usually delayed to such an extent as to be ineffective in forestalling cost in day-to-day operations. Such records, however, afford a valuable source for post-mortem examinations of a retroactive nature.

The importance of timing in productive maintenance would be difficult to overemphasize. The right steps must be taken at the right time — if cost is to be consistently reduced.

High power cost is a form of economic attrition that few industrial organizations can tolerate for long periods of time. The writer firmly believes the intense competition for gross profit dollars is destined to remain with the oil industry for a long time. Consequently, closer control of power cost will be necessary to sustain the highest investment qualities of oil stocks in the future.

Production of low cost power is basically a matter of know-how — more so than a function of the business cycle. This kind of know-how is a strong contributing factor to Western Germany's rapidly growing industrial strength. This kind of know-how can bolster profits in prosperity and recession alike. Thus, the trend will be to include the responsibility for power production cost in the maintenance functions.

Productive maintenance organizations have demonstrated ability to produce low cost power regardless of business conditions. The complex nature of low cost production renders it a form of economic attrition too gradual to be recognized before profit erosion is well advanced. Consequently, low cost power production and full-profit responsibility are inseparable. There are few industrial firms that could not reduce their power cost. The oil industry has much to gain by insisting on more economical power production.

Maintenance Futurama

If we would know something of the future of maintenance, we must know its past. The past 12 years of maintenance history have been fraught with drastic change and unparalleled progress. The contributions that maintenance has made to industry welfare bear but small relation to what it can and will make in the future.

There exists a current, but widely held misconception that all or most of these changes have been due to automation or unattended control devices. On the contrary, these improvements have been largely due to improved materials of construction, modern mechanical construction and pumping equipment, and major improvements in controls, instruments, and electronics. These major improvements constitute the foundation upon which creative imagination and hard work have erected our modern pipeline industry.

There is likewise, the misconception that a new era in pipeline operations is being currently conceived in the minds of engineering and planning. On the contrary, we have already crossed the threshold of that new era in pipeline history. The materials, devices, and controls are now available with which to gather oil from field leases to a central metering point, dispatch it, and deliver crude oil and products to distant destinations automatically.

Automation is here to stay. We cannot disinvest it nor can we successfully obstruct the path of its progress. Occasional anti-technological sentiment will soon give away to supportive operation. The problem is to learn to live better by and with automation. Thus, the automation era has thrust upon maintenance the inescapable responsibility to upgrade maintenance skills and personnel; lest maintenance become a barrier to full realization of the potential benefits of automation.

Temporarily assuming the role of "stormy petrel," the writer believes the greatest challenge for maintenance personnel may well lie in the next 20 years. There is little reason to believe that automation is going to solve all of our problems — nor is it going to create widespread unemployment. On the contrary the verdict of industrial history has been that technological advancement creates jobs more rapidly than it destroys them.

History likewise has proved that mankind has always sought after and applauded that which is new. For example, in 12 out of 15 plants studied, employment is higher than it was prior to automation, and in some cases their employment exceeds that of pre-automation days as much as 40 percent.

Generally, automation eliminates some operative jobs but creates more maintenance and non-automated jobs. Automation will greatly increase the demand for skilled men; however, the supply is shrinking. Obviously, the demand for people trained in manual skills is great, and will continue to grow steadily in the next decade. The wages and recognition of skilled maintenance workers will continue to increase; and productive maintenance will take a back seat to no other part of the industrial parade.

The increasing importance of productive maintenance will result in part from the tremendous accumulated replacement needs of American industry, which has become an old-equipment industry. Recent surveys indicate the petroleum industry alone would be required to spend $5.3 billion should it decide to replace all obsolete facilities with the best new plant and equipment.

During the next decade all economic weathervanes indicate we are certain to face capital shortages. Therefore, old equipment and tight money places an added emphasis on productive maintenance for several years to come.

The writer has attempted to demonstrate how productive maintenance can contribute to profit maintenance by looking well ahead, catching sight of and applying trends early.

The further advance of maintenance and its greatest potential is yet to be developed along the frontiers of pre-installation maintenance. This phase of maintenance involves its lesser known functions; viz, eliminating maintenance, arresting depreciation, and forestalling obsolescence. Forestalling obsolescence is the act of postponing, hindering, or preventing equipment from becoming prematurely outmoded. Pre-installation maintenance is the best method of forestalling obsolescence. Properly executed, it begins with the design and selection and continues through the installation and testing of equipment. Thus, the maintenance engineer also can contribute materially to solution of the challenge ahead.

Conclusions

Maximum profit with minimum investment is possible with a productive maintenance program. The results of this type of operation can be evaluated and accurately measured if adequate records are kept.

In the era of old equipment and tight money that lies ahead, all industrial operators should realize there is no such thing as no maintenance program — it follows by plan or default. Thus, industry should not fail to apply productive maintenance techniques — nor fail to develop and recognize skilled maintenance personnel and their contributive potential.

Maintenance has now become a big part of big business. ★ ★ ★

Leidy station stands atop Tamarack Mountain on the Finnefrock Farm, site of the prolific Finnefrock Well, which flowed 145,000,000 cu ft a day at its peak and was the largest well ever drilled in the East.

Gas Storage at 5000 Psi

Imposes Unconventional Construction Methods

Heavy wall pipe — 0.718 to 1.312 in. — controlled procedures for Leidy field installation . . . 22 passes required for field weld, 30 automatic and 4 hand welds in double jointing plant . . . welds X-ray inspected and stress relieved 100 percent

Floyd Trillis, *Mechanical Engineer, New York State Natural Gas Corporation*

LEIDY GAS STORAGE FIELD in north-central Pennsylvania, developed by New York State Natural Gas Corporation in conjunction with Transcontinental Gas Pipe Line Corporation and Texas Eastern Transmission Corporation, is now operating in its initial phase and delivered approximately 12 billion cu ft of gas during the 1959-60 season. Ultimately deliveries will reach 60 billion cu ft.

The decision to utilize the reservoir of this once prolific field to optimum capacity, that is, at original rock pressure, necessitated a surface injection pressure of 5000 psig and a maximum operating pressure of 4200 psig, making the facility unique among storage installations.

Certain construction problems were the result of this departure from traditional operating conditions. The most significant phases will be discussed in this article.

Selection of Materials

An important component of this storage facility is the network of pipelines serving the various wells within the pool. The initial stage in the development of the pipeline injection system entailed the construction of 13 miles of 12-in. pipe extending the length of the storage pool, and 22.5 miles of 6, 8, and 10-in. lateral lines serving the 85 wells within the pool.

The critical pressures justified a thorough analysis in the matter of materials selection. Certain safety and economic considerations generally are the criteria for basic design, whereas the necessary stress levels are mathematically determined by utilizing certain materials and predetermined factors. Safety factors based on tensile strength vary with the material for any given condition, so the material specification becomes an important consideration.

One of the first approaches to Leidy storage development was that of material correlation. Questionnaires were forwarded to various parties involved in operating conditions of this nature and magnitude. These disclosed that 4 and 6-in. lines were being employed in the Southwest in conjunction with cyclic activities, and that small quantities of larger pipe were being utilized in compressor station and process work. Lower yield strength materials had been used exclusively in these installations and were highly recommended for this particular project.

In the past decade, certain new materials have been introduced employing higher working stresses, which are more economical to use. Naturally, they also deserved serious consideration. Therefore, an endeavor was made to investigate these materials to assess their applicability to this particular service. In considering these higher yield strength materials there were certain limitations requiring attention. Using these materials inadvertently meant lower safety factors, as the yield strength became a greater percentage of the tensile strength. Additionally, these newer materials were generally accompanied with lower ductilities and higher notch sensitivities — to a degree not well defined — than the time-honored lower yield strength materials.

Naturally, the question arose as to whether these limitations were justified by the utilization of more exacting design, fabrication, and inspection procedures. This was not aptly defined by the evidence at hand. Heretofore an accurate assessment of the loading conditions on underground pipeline systems was not readily available. As for the new materials, their behavior under the various service conditions was not too generally known. These uncertainties left much to be desired in these particular areas. Thus for the sake of structural soundness it was considered advisable to employ the lower yield strength materials, assuring less susceptibility to failure.

Heavy Wall Pipe Used

By virtue of the 5000-psi pressure rating involving heavier walls and greater thickness/diameter ratios, the piping design took on a different aspect

because it was necessary to consider both the membrane stress formulae and the thick wall formula.

Therefore, in establishing the wall thicknesses, several of the most commonly used formulae were investigated. These formulae yielded results of great similarity, and on this basis the Transmission Formula was chosen for wall determinations.

Suitability of the Gas Transmission Code to these operating conditions was also questioned and the matter submitted to the ASA B31 Sectional Committee, which adjudged the Gas Transmission Code adequate to this particular case.

In view of these circumstances it was decided to apply the Gas Transmission Code in its entirety.

The design, fabrication — both factory and field — and inspection specifications were proportioned to the materials selected and the intended service. Some of the problems associated with fabrication were quite interesting and in certain cases were a matter between New York Natural and the manufacturers and contractor, depending on the nature of the work.

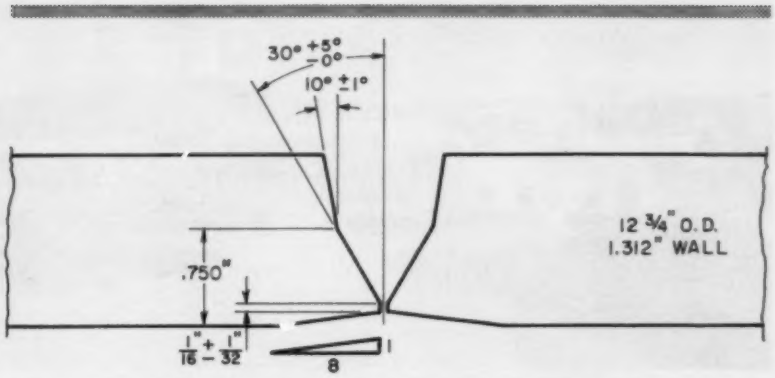


FIG. 1. Pipe mills were required to make a special end finish to provide an accurate and faster line-up.

Pipe Line-up Difficult

As a case in point, preliminary investigations indicated that some difficulties would be encountered in joint line-up preparatory to welding. For example, by virtue of the heavy walls employed it was necessary to revert to external pipe clamps because of the impracticality of devising an internal clamp with sufficient force to be effective, i.e., form the end of the pipe into a perfect round.

It is common knowledge that a concentric ID-OD pattern at the weld ends in most cases is not achieved effectively in the manufacturing process. Therefore, as a further aid to pipe alignment it was decided to true-up the internal diameter with respect to the outside diameter at each end.

Accordingly, each joint of pipe was furnished with a special end preparation at the mill, as illustrated by the internal taper on Fig. 1. This afforded a more accurate and faster line-up in the field with the use of external clamps. These advantages more than offset the premium paid for this specified requirement.

Despite these innovations, line-up was fairly difficult. Line-ups on welds involving fittings were extremely difficult, as were those involving pipe that was field cut and beveled, wherein it was impractical to reproduce the internal bevel.

The pipe was all supplied by the manufacturer to API-5L Grade B specifications and was the largest order placed at that company for heavy wall pipe by a single customer. This pipe, all seamless, was designed for 5000-psig working pressure, according to ASA B-31.1.8-1955, Class A construction. The pipe requirements were as follows:

13 miles of 12-in. x 1.312-in. wall; 1 mile of 10-in. x 1.125-in. wall; 2 miles of 8-in. x 0.906-in. wall; 19.5 miles of 6-in. x 0.718-in. wall.

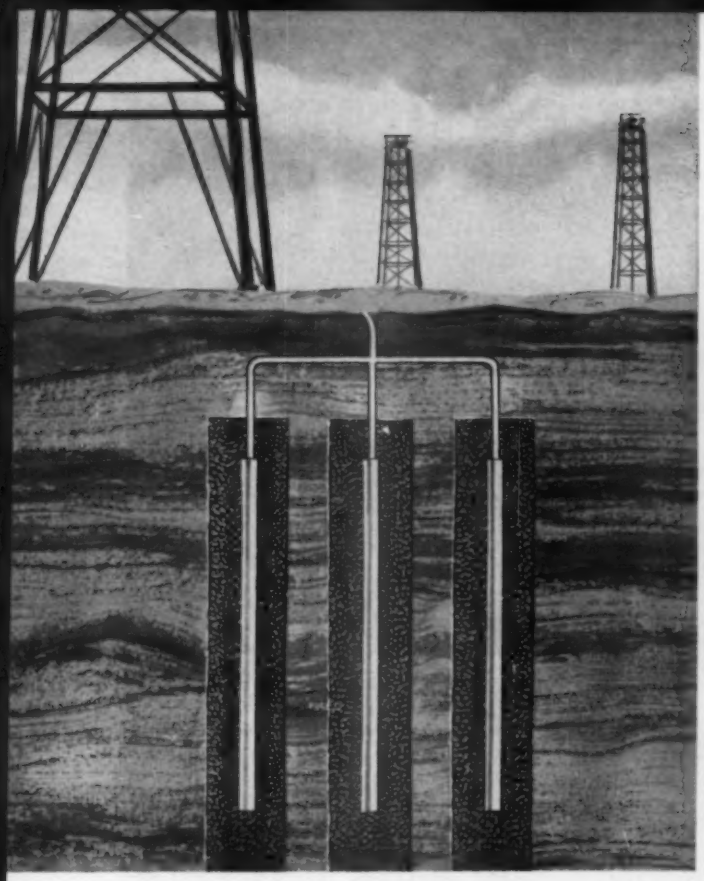
The 13 miles of 12-in. pipe were supplied mostly in 22 to 35-ft lengths, the joints averaging about 33 ft.

Unconventional Construction

It is common practice in pipeline construction to determine the procedures and equipment according to the pipe size, wall thicknesses being of secondary importance. Field assembly and installation of the pipe differed from the conventional because of the heavy pipe walls, which was of greater

Extreme pressures necessitated use of pipe with unusually thick walls. Wall thickness of this 12-in. is 1.312 in.

Double jointing required four hand welds and 30 passes with submerged arc welding equipment.



for underground structures make

Duriron®

impressed current Anodes

your guarantee for cathodic protection

Duriron Anodes have proven their superiority for the cathodic protection of pipelines, drilling rigs, well casings, storage tanks, gathering lines, communications cables, and similar systems. In all perfect backfill cases (where the anode is merely the conducting rod) Duriron serves exactly the same purpose as graphite, and just as well. And in the really tough cases, when backfilling is impractical or imperfect, Duriron Anodes are better.

Duriron Anodes have unexcelled corrosion resistance; good electrical properties; no current density limitations; no undesirable corrosion products, and they are easy to install.

Durco high silicon cast irons are resistant to sea, brackish and fresh waters as well as all soil environments. Write now for Bulletin DA/6.

STANDARD DURIRON ANODE SIZES

Type Anode	Size	Area Sq. Ft.	Weight (Lbs.)	General Application
B	1" x 60"	1.4	14	Fresh Water
C*	1½" x 60"	2.0	25	Ground Bed
D	2" x 60"	2.6	46	Ground Bed
E	3" x 60"	4.0	115	Salt Water
G	2" x 9"	0.4	5	Ducts
J	3" x 36"	2.5	80	Salt Water
M	2" x 60"	2.8	57	Salt Water

*Applicable also in fresh water service. Should not be used in ground beds without backfill.

THE DURIRON COMPANY, INC.
DAYTON, OHIO

DURCO

Gas-operated stress relieving furnaces were used during double jointing operations. Welds were heated to about 1200 F, after which they were gradually cooled at a rate not to exceed 400 F per hr. Cooling was controlled by covering the welds with heavy asbestos blankets.

Gas-fired annealing furnaces were used on field joints to relieve stresses set up by welding. Twelve furnaces were operated simultaneously. Temperatures for each joint were relayed to the bus where an operator using a potentiometer directed heat regulation through a loud speaker.

consequence than indicated by the size of the pipe. This is best illustrated by the fact that although the pipe was 12 in. diam and under, it was necessary to utilize equipment normally required for 30-in. pipe.

Usually welding is a simple matter, but related to this project it became more complex. The following illustrations will give an idea of some of the problems encountered.

Due to the tremendous force exerted by the weight of the pipe, some difficulty was experienced in handling and assembling it, particularly on steep slopes. Fluctuations in ambient temperatures, especially on hot days and extremely cool nights, and attendant contraction and expansion of the pipe, made it difficult to fit the pipeline to the contour of the ditch. This was of greater significance on steep slopes, necessitating pipe restrainment by means of cables.

In connection with jointing at slopes, some difficulty was anticipated with alignment, pull-out effects, etc., but these were performed without incident. The downhill welding technique was employed.

Because of weight — 160.3 lb per ft — and mechanical properties, the pipe yielded quite readily and consequently conformed well to the high and low points in the ditch bed.

In this respect it might be mentioned that cold bending of the pipe was performed with great ease.

On the other hand, supporting the pipe was quite troublesome. The skid breakage involved is difficult to conceive. Normal replacements were exceeded by three to four times.

Field Weld: 22 Passes

Each 12-in. field weld required 22 passes in addition to the root bead, and 5½ hr to complete. A strong tendency existed for slag to be trapped in the portion of the compound bevel immediately above the stringer bead. This problem beset the welders at the beginning, but in due time the situation was corrected through practice and experience. Although some inclement weather was encountered during the construction period, the effect on the welding operation was slight.

For comparative purposes the weight of the 12¾-in. OD, 1.312-in. wall pipe was 160.3 lb per ft and this is equivalent to a pipe 30 in. OD with a 0.500-in. wall. The fillet volume per weld was 28.6 cu in. for the 12-in. pipe as compared to 14.1 cu in. for a 30-in. pipe.

Double Jointing Adopted

In view of the tremendous effort involved in making a weld on this heavy wall pipe it was readily apparent that double jointing at a central location had high merit. Double jointing on a production basis meant quick and accurate line-up and better weld consistency.

Double jointing was performed with a semi-automatic welding machine using the submerged arc method. Each weld required a root bead and three hot passes by hand and approximately 30 passes with the machine. Total welding time for each weld was 1 hr, which is considerably lower than the 5½ hr required for field welds.

Each weld was X-rayed and then stress relieved. This phase of the work was performed by the contractor for the storage field piping.

In view of the critical pressures involved, the merits of a partial X-ray program were considered doubtful and therefore it was decided to X-ray 100 percent. This was also true for preheating.

Every weld was visually examined by New York State Natural Gas Corporation welding inspectors and X-rayed as completed by an X-ray contractor.

Few Weld Rejects

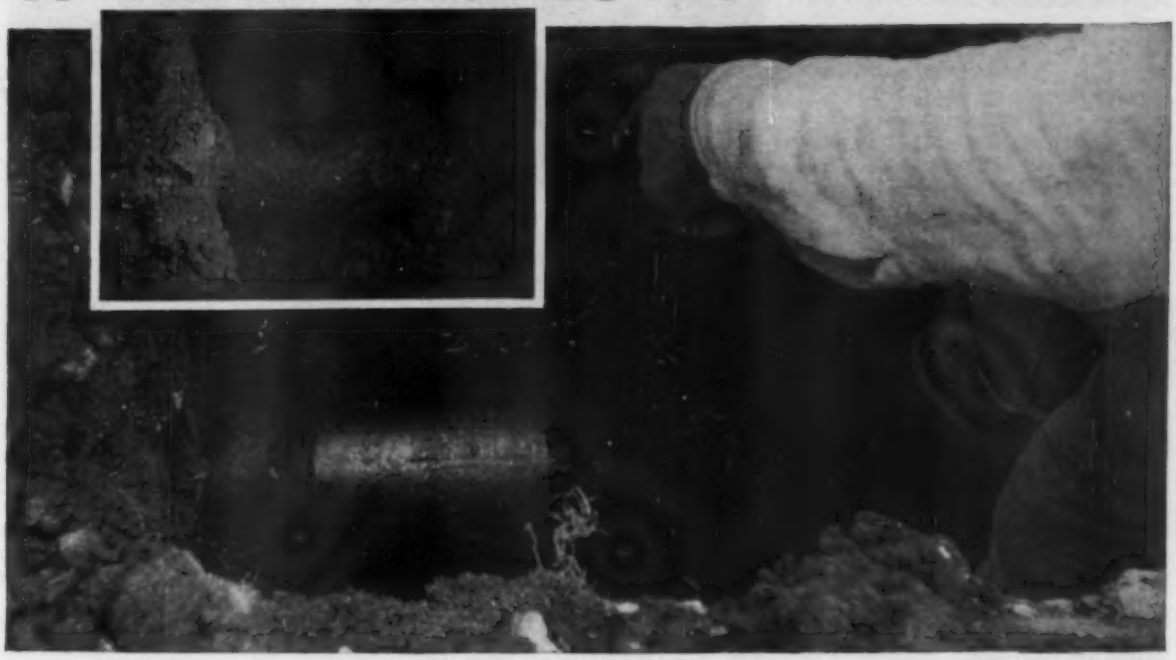
The psychological effect exerted by this program was well worth the additional costs involved, as demonstrated by the results attained. Of approximately 2000 welds on the 12-in. pipe there were only 36 rejects, a rejection of less than 2 percent. Added construction costs as reflected by weld rejection were an important consideration, since the cost of replacing a defective weld was several times that of an ordinary weld.

The system was hydrostatically tested to 6000 psig.

Welds Stress Relieved

Stress relief was required on all welds whose thickness exceeded 1¼ in. Temperature was first raised to 600 F in not less than 20 minutes, then increased evenly at 300 F per hour to 1200 F. It was held there for 1½ hr

17-YEAR PROTECTION RECORD!



Year After Year...More Evidence Proving That TAPECOAT Adds Years of Service Life to Gas Lines Underground or Under Water

Right across the country, TAPECOAT installations prove that you get more for your money when you measure pipe protection with a calendar.

Since this cost-cutting coal tar coating in tape form was first introduced in 1941, it has demonstrated its ability to withstand severe conditions underground or under water. TAPECOATED lines dug up after 17 years of service show no signs of deterioration on the pipe.

Typical is the experience of a utility in a coastal area. For a thorough trial, this company applied TAPECOAT in areas where severe corrosive conditions were known to exist. The lines were dug up this year and, after years of service under severe conditions such as brackish waters and corrosive soil, the pipe showed no signs of corrosion, proving the quality of TAPECOAT protection.

In terms of preventive maintenance and replacement costs, performances like this emphasize the most important consideration in buying protection. Remember, TAPECOAT is a hot-applied coal tar coating in tape form—designed for lasting protection on pipe, pipe joints, service connections, mechanical couplings, fittings, insulated lines, tanks, tie rods, and other steel surfaces vulnerable to corrosion.

TAPECOAT comes in rolls of various widths and is available in asphalt. Where primer is desired, specify TC Primecoat, the compatible coal tar primer.

A TAPECOAT sales and service engineer is always available to help you on any corrosion problem. Write for complete details today!

GEM

TAPECOAT®

The TAPECOAT *Company*

ORIGINATORS OF COAL TAR COATING IN TAPE FORM

1533 Lyons Street, Evanston, Illinois

REPRESENTATIVES IN PRINCIPAL CITIES

and then cooled at a rate not exceeding 400 F an hour. Cooling from 400 F was accomplished by means of a heavy asbestos blanket wrapped around the weld.

The stress relief cycle was achieved by means of furnaces specially constructed from heavy gage plate by the contractor. These cylindrical chambers with an axial opening for the pipe were designed in two halves to permit quick assembly and attachment to the pipe. The bottom portion was placed under the weld and the upper part lowered to meet it, thus forming a tight fit completely around the pipe. To facilitate the movement of each unit to the next location, plastic hoses were used to serve the natural gas requirements of each furnace.

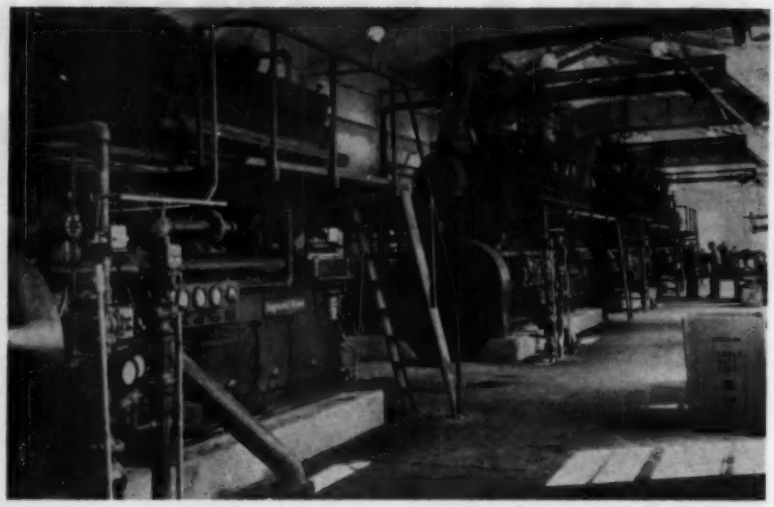
For various economic, operational, and functional reasons, the gas-fired furnace was selected over an electric resistance unit. The number of furnaces constructed was primarily based on economics and the construction schedule. Because of the unlikely possibility of re-employing these furnaces it was necessary to write off their total cost to this project. This expense, therefore, was an important consideration in determining the number of furnaces to be constructed. Total cost per unit was about $2000.

The stress relieving cycle was conducted on a 24-hr basis entailing two 12-hr shifts. This operation required the services of an operator stationed on a mobile unit, three assistants attending the furnaces, and the necessary men and equipment to redeploy these units.

The heating cycle itself required about 6 hr; the remaining 6 hr were devoted to redeployment, which was performed as one integral unit rather than on an individual basis. The mobile unit, a converted bus, was located midway between the end furnaces, which were 700 ft distant. Working schedules were so arranged and the work progressed in such a manner that the distance between the stress relief and welding operations was held fairly constant, being about 1500 to 2000 ft.

Furnaces Coordinated

A unique feature of the stress relieving operation was the manner in which the 12 furnaces were coordinated during the cycle. The cycle for each weld was recorded by means of a recording electric potentiometer mounted in a converted bus and connected to a thermocouple that was tack welded to the weld. Temperature adjustments at each furnace were made by personnel as directed by an operator stationed in the bus and using a loudspeaker. Inclement weather affected the stress relieving cycle to some degree, but it was less vulnerable to high winds than to rain or snow.



Interior view of compressor building shows three 2000-hp engines at right and one of the two 1000-hp engines at left during breaking-in period. Ultimately the station will have 15 engines and a total of 27,000 hp.

Valves and Drips

All pipeline valves were Series 2500 weld-end gate valves and were ordered with an outlet extension on each end, two pipe diameters in length. This was done to accommodate the stress relieving furnaces and also to preclude (1) any damage to the valve from the furnace heat or (2) any possibility of a bad field weld at the valve.

The wellhead and field line drips were prefabricated and 100 percent radiographically inspected. These are stepladder type drips and were designed according to ASA B31.1.9-1955 Class A, Type B construction for an operating pressure of 5000 psig. The material conformed to ASTM A-106 Grade B specifications.

Each wellhead assembly consisted of two 5-in. lead lines with a 5-in. orifice fitting incorporated into one of the lead lines. These also were prefabricated according to the above ASA schedule. The material conformed to ASTM-A-53, Grade B Specifications.

Compressor Station

Heart of the storage operation is a compressor station situated approximately in the center of the pool. When ultimately completed, this station will have 15 engines with a total of 27,000 hp.

Leidy storage is being developed and will be operated by New York State Natural Gas Corporation, which has a half interest. Transcontinental Gas Pipe Line Corporation and Texas Eastern Transmission Corporation each have a one-fourth interest in this joint venture.

The initial phase, now in operation and providing about 12 billion cu ft for Transco's customers during the 1959-60 season, ultimately will provide 60 billion cu ft of top gas when Texas Eastern and New York Natural elect to store gas in the pool. Cushion gas will amount to about 45 billion cu ft.

When fully developed, the pool will be operated at a maximum pressure of 4200 psig with surface injection pressures approaching 5000 psig. Gas will be delivered to the three participating companies at 1200 psig. This differential will make large quantities of peaking gas available. It is estimated that the pool will deliver 800,000,000 cu ft per day when 93 percent of the top gas has been removed. ★ ★ ★

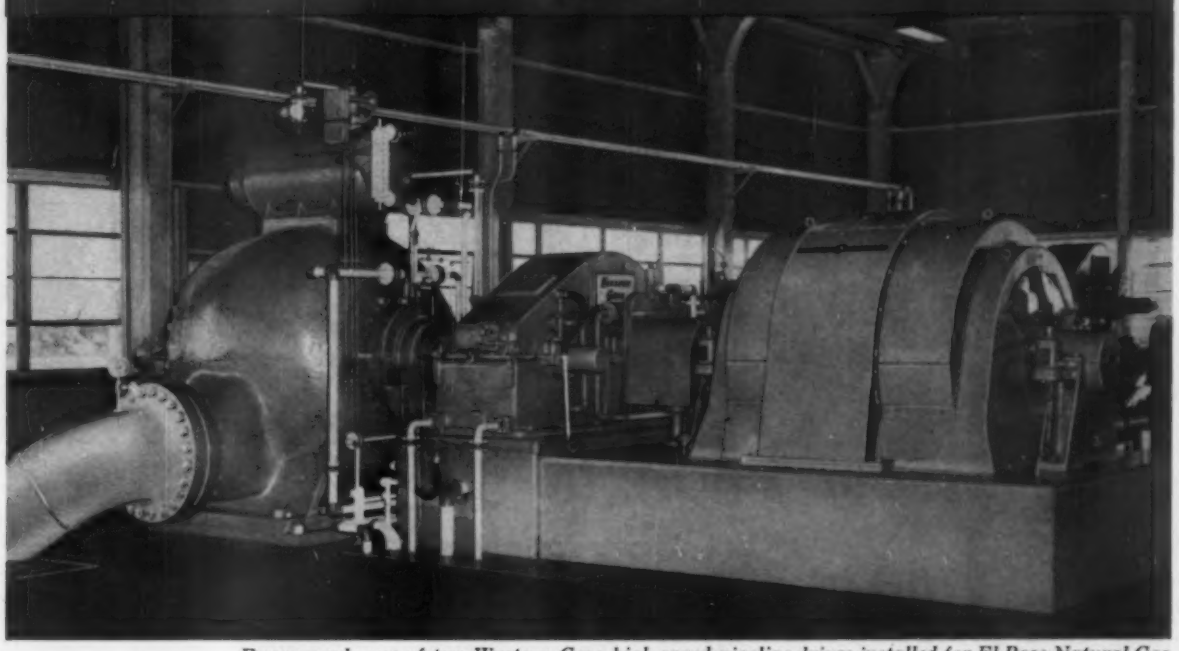
Floyd Trillis *was born January 15, 1925, in Wheeling, West Virginia and attended Edgewood Grade School and Follansbee High School in that state. He is a 1949 graduate of West Virginia University, Morgantown, with a BS degree in mechanical engineering.*

Trillis began his career in 1949 as an industrial engineer with the Left Fork Fuel Company, Quinwood, West Virginia. He later became a resident engineer for that company. During this same period, he acted as a town engineer for Lewisburg, West Virginia. He held both of these positions until 1956 when he joined the engineering staff of New York State Natural Gas Corporation as a mechanical engineer, the position he still holds.

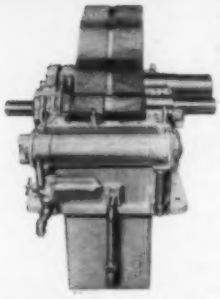
Trillis is a veteran of the second world war, having served a two-year enlistment in the U. S. Navy. He is a member of the West Virginia Professional Engineers Society, the West Virginia University Alumni Association and the West Virginia University Engineering Alumni Association.

WESTERN GEAR

pipeline drives on stream at EL PASO NATURAL'S LEUPP STATION



Foreground: one of two Western Gear high speed pipeline drives installed for El Paso Natural Gas Company in its Leupp Station, Leupp, Arizona. Both drives are catalog model 300 HS 150 units, rated at 5750 h.p., with input of 1200 r.p.m. and output, 8494 r.p.m.



on the long run...

QUALITY COSTS YOU LESS!

Where there is obviously no compromise with quality, you'll find Western Gear. El Paso Natural Gas Company's Leupp Station, using the Ingersoll-Rand compressor powered by a General Electric Motor, is an example of reliance on Western Gear where performance and dependability are vital.

Pipeline companies throughout the world rely on Western Gear hi-speed gear units. Western Gear single stage pipeline drives are in use by Texas Eastern, Transmountain, Warren Petroleum, Union Oil, Trans-Arabian, Petroleos Mexicanos, Spanish Pipeline, Richfield Oil, Great Lakes and Mid Valley. Transwestern and Columbia-Gulf, using engine driven centrifugals are equipped with two stage high speed units, an application pioneered by Western Gear.

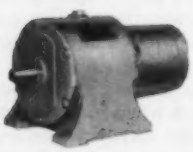
But pipeline experience is not the whole story. At Western Gear, many products are built requiring extremely close tolerances and rigid quality controls, including Magnafluxing and X-Ray and ultrasonic inspection. These range from 45,000 h.p. marine drives to highly loaded, lightweight gears, and super-precision drives for speeds to 100,000 r.p.m. and gear pitch line velocities approaching the speed of sound.

In such an environment, design and production of high speed pipeline drives falls easily within the scope of Western Gear's everyday experience.

For full information on Western Gear pipeline drives, write, wire or phone: WESTERN GEAR CORPORATION, Industrial Products Division, P.O. Box 126, Belmont, California, Phone LYtel 3-7611.

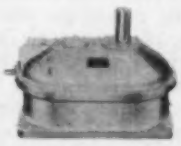
WG INDUSTRIAL PRODUCTS DIVISION

OTHER WESTERN GEAR POWER TRANSMISSION CATALOG PRODUCTS



INTEGRAL GEARMOTOR

PARALLEL SHAFT REDUCER

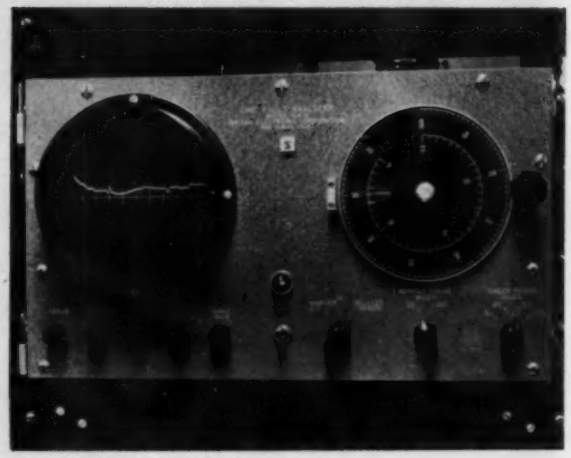


VERTICAL SHAFT REDUCER

HIGH SPEED UNIT

RIGHT ANGLE REDUCER

W. E. Bryan, general office communications department, using Line Fault Analyzer to locate trouble on one of United's telephone circuits.



Closeup view of the Line Fault Analyzer.

Fault Analyzer Pinpoints Wireline Trouble

Fast restoration of telephone and telemetering channels results from United's streamlined system

DEPENDABLE communication has always been a must in maintaining dependable natural gas service, and, in this age of scientific wonders and rapid communications, United Gas Pipe Line Company has a streamlined system of pinpointing trouble along its thousands of miles of telephone lines.

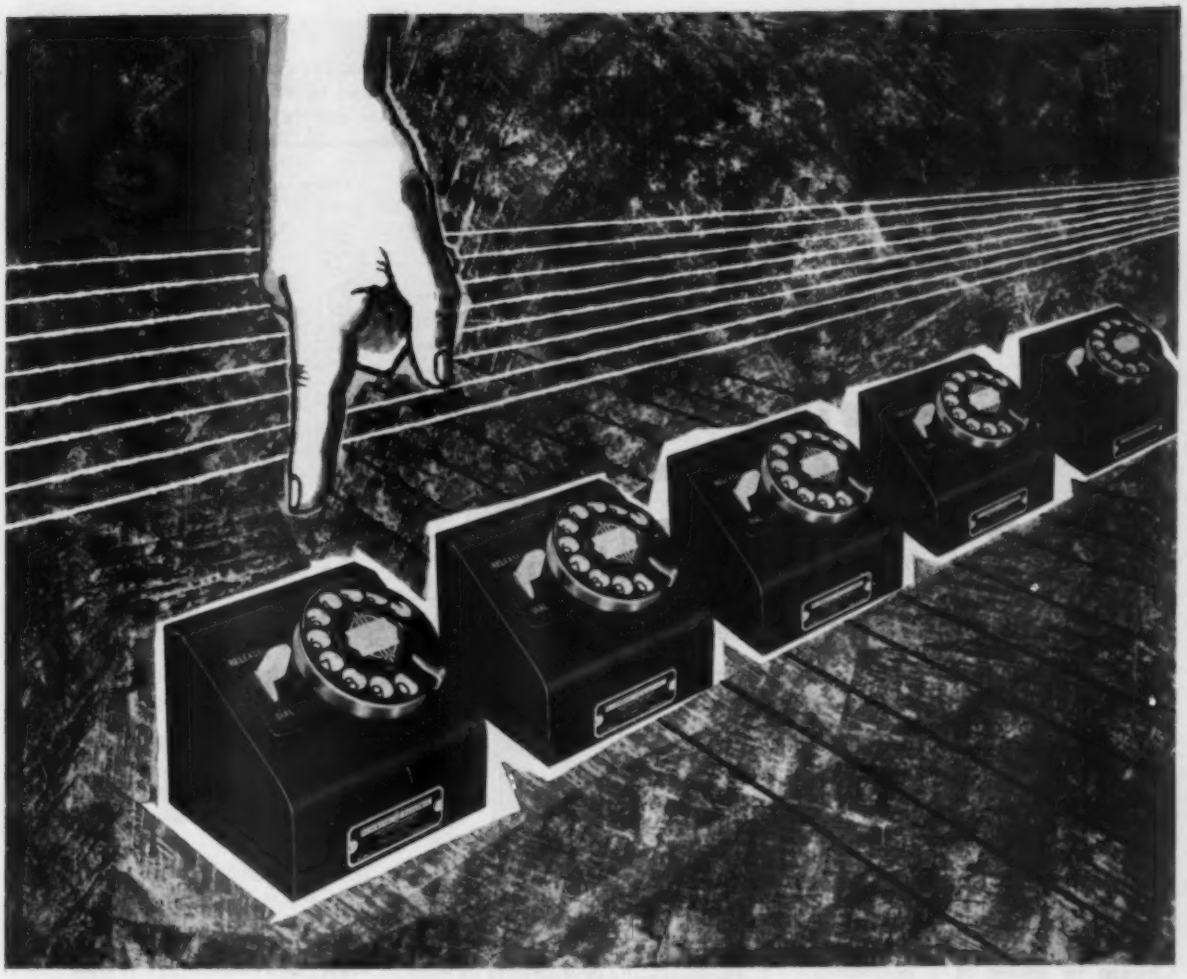
The trouble-finding system is centered in an instrument called a Line Fault Analyzer located in the general office communications department at Shreveport, Louisiana. Weighing less than 60 lb, the small radar-like instrument is specifically designed for rapid location of faults on wireline systems; and it can tell its operator within a few feet of where the cause of trouble will be found, up to 200 miles away.

Quick restoration of telephone and telemetering channels is a vital link in supplying the natural gas requirements of more than a half million United Gas customers; and old timers in communications recognize the many hours of outage time saved by the Line Fault Analyzer, not to mention the untold miles of walking, climbing, and searching it has eliminated.

United Gas dispatchers rely on the company-owned telephone system in regulating the flow of natural gas throughout the company's extensive pipeline system. Quick telephone calls and continuous telemetering over the same wires contribute immeasurably to maintaining proper gas pressures and assurance of dependable round-the-clock service; and of course, in the event of service problems of any nature along the pipelines, the telephone system might mean the difference between a community without gas and one with uninterrupted service.

As used on United's telephone system, the Line Fault Analyzer does just what its name implies. It analyzes the situation along a circuit when trouble occurs. Line faults such as wire breaks, short circuits and grounds are easily recognized and their location determined by noting the distance from the fault to the nearest known point on the line. A dial, calibrated in fractions of a mile, provides an accurate means of reading distances directly. The nature of the fault is indicated by the type of "pip" displayed on an oscillograph screen, a broken wire producing a differently shaped pip from a short circuit, ground, or other type fault.

Information as to the location and nature of the fault when passed on to line crews by radio, speeds repairs and eliminates delays in restoring circuits to normal operation. ★ ★ ★



Now—automatic dialing all along the line

AE's simple and inexpensive Waystation Dialing System ties your message lines into your automatic exchange *without replacing present equipment.*

The result? Fast, economical dial service throughout your entire telephone network . . . without calls having to pass through dispatchers or switchboard operators. The system provides modern dial service *directly from waystation to waystation, from automatic exchange to waystation, and from waystation to automatic exchange.*

All you need is one inexpensive control unit for each message line to be tied into your automatic exchange, and a simple dial unit at each local-battery telephone.

For full facts, call your local Automatic Electric sales representative, or write Howard N. Inwood, Director, Railway/Petroleum Industry Sales, Automatic Electric Sales Corporation, Northlake, Illinois.

CHECK THESE FEATURES

- Control Unit and Dial Unit are fully transistorized.
- Dial Unit operates from two 1.5-volt dry cells for dialing ranges up to 60 miles. For longer distances, simply add dry cells.
- Dry cells have long life because battery power is used only when dialing.
- Dial Unit is easily installed; it connects directly to the terminals of any local-battery telephone.
- Dial Unit uses tone signaling — does not upset or interfere with the d-c circuits.
- System permits dialing over existing conversations in cases of emergency.

AUTOMATIC ELECTRIC

Subsidiary of

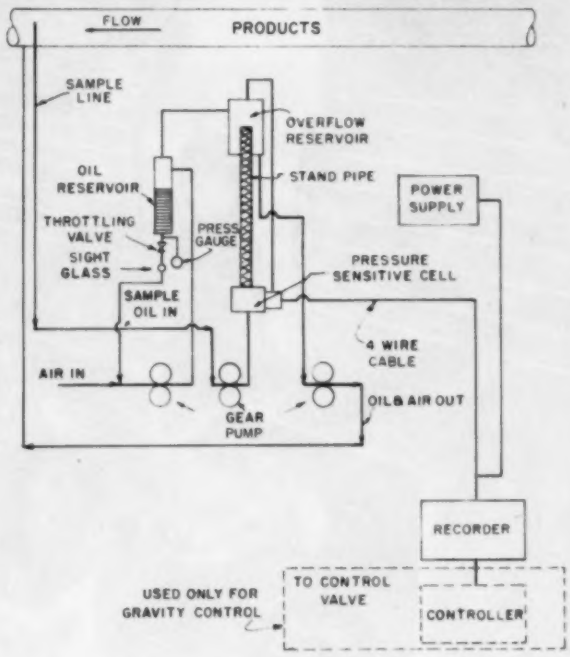
GENERAL TELEPHONE & ELECTRONICS

Products Delivered Automatically With Gravitometer

Gravity differences of only 1.0 to 2.0 deg API are necessary for successful performance

Henry A. Brainerd
Robert N. Warren
Sinclair Pipe Line Company

FIG. 1. Flow diagram of the gravitometer system showing the flow of products and air along with the electrical connections pertaining to gravity measurement and control.



SINCLAIR PIPE LINE COMPANY, since June 1959, has been making automatic deliveries of various oils into tankage at its Hartsdale station near Chicago by means of a continuous recording gravitometer.

Here is how it works:

As a product change arrives at the tank line manifold, the interface is detected by the gravitometer. When the gravity of the interface reaches a preset valve, the gravitometer automatically switches the flow to the proper tank for the new product.

The necessary settings to effect this change can be made many hours before the actual interface arrives because the automatic delivery is made solely by the change in gravity between the two products.

The inherent accuracy of the gravitometer (± 0.1 deg API with a range of 30 to 70 deg API) and its associated recorder (± 0.1 deg API) makes it possible to execute automatic deliveries between products having small gravity differences. Half of the automatic deliveries so far have been made between products with gravity differences of 1.0 to 2.0 deg API. The automatic delivery system has made these deliveries without difficulty, and with care it should be possible to make automatic deliveries between products with gravity difference as small as 0.5 deg API.

Developed at Sinclair Lab

The Sinclair-Cenco gravitometer was developed in 1957 at Sinclair's Research Laboratories in Harvey, Illinois. It was specifically developed to be used as an automatic crude oil blending device at a main station. This automatic blending was designed to control the outgoing gravity blend to an accuracy of ± 0.1 deg API. The blending system, using the prototype gravitometer as the control instrument, was field tested for a period of approximately 18 months with throughputs varying between 200,000 and 300,000 bbl per day. This extensive testing proved the gravitometer control system could control the crude oil blend to the desired tolerance.

The highly successful performance of the original gravitometer, both as a recorder and as a blending controller for crude oil, resulted in two significant decisions.

First, the Central Scientific Company was licensed to manufacture the gravitometer.

Second, it was decided that this instrument should be suitable for making automatic product deliveries.

The logical consequence then was to field test the first commercial gravitometer as an automatic product delivery device. Hartsdale station was selected for this test because operating conditions were favorable and it was within easy access of the Sinclair Research Laboratories.

How Gravitometer Works

Before discussing the automatic deliveries in detail, a brief explanation of just how the gravitometer works may be helpful. Referring to Fig. 1, the heart of the gravitometer is a standpipe containing a flowing column of the sample and a differential pressure strain gage that measures the pressure created by the static head of the liquid column. The flow rate is kept quite constant and a surrounding temperature controlled oil bath keeps the temperature of the liquid sample constant (107 F) to within ± 0.1 F. Since a differential pressure strain gage is used, both sides of the bellows are exposed to system pressure and any variations in system pressure will not affect signal output.

Under the conditions stated, the pressure indicated by the strain gage will be directly proportional to the specific gravity of the flowing liquid. Also, because the temperature of the sample, when measured, does not vary, the gravitometer output can be calibrated to read API gravity at 60 F regardless of the sample temperature when it entered the gravitometer. A small distortion is introduced by meas-

newest · fastest · most efficient

16" to 36" CROSE
internal cleaning and coating machine
. . . for sale or lease

WITH THESE SPECIAL FEATURES . . .

- Only two basic cleaning heads required for all pipe sizes from 16" through 36".
- Retractable brush unit minimizes pipe entry damage. Pressure of high speed circular wire brush indicated on operator's console — for easy adjustment during operation.
- Large capacity continuous operation vacuum pickup system removes refuse during cleaning and coating operations.
- Airless type coating spray system utilizes hydrostatic pressure to atomize paint . . . eliminates 90% of overspray and coating bounce-back.
- 360° spray head eliminates build up or lap at juncture of spray pattern.
- Operator controls machine operation from centralized push button console . . . he does not have to ride boom car.

CLOSE-UP VIEW OF CENTRALIZED PUSH BUTTON CONSOLE.

CROSE announces the newest development in pipeline construction equipment. The Crose internal cleaning and coating machine is the fastest, most efficient machine on the market, requires only two basic cleaning heads for all pipe sizes from 16" through 36", and is available on a for sale or lease basis. This electric-driven machine comes complete with pipe handling and spinning rack. Requires a minimum crew of four men . . . can be moved easily from one job site to another, or can be permanently installed.

WATCH FOR ANNOUNCEMENT OF DEMONSTRATIONS IN TULSA AND HOUSTON.

Crose perrault
EQUIPMENT CORP.

2765 Dawson Road • Phone WEbster 6-2171 • Tulsa, Oklahoma • BRANCH OFFICES: Houston, Texas • Elizabeth, New Jersey • IN CANADA: Edmonton, Alberta • Toronto, Ontario • EXPORT OFFICE: New York, N. Y.

uring the sample at 107 F to record its gravity at 60 F, but this distortion is appreciably less than 0.1 deg API.

Appendix "A" gives a detailed mathematical evaluation of this slight distortion. The output signal from the gravitometer has a range of 0 - 2.5 mv and can be fed into any acceptable recording potentiometer with that range. Standard instrumentation techniques can then be employed to use this signal for automatic blending, automatic deliveries, etc.

A number of refinements, such as keeping the system under sufficient pressure to eliminate vapor bubbles, have not been mentioned, but an understanding of these features is not essential to comprehend the basic operation of the instrument.

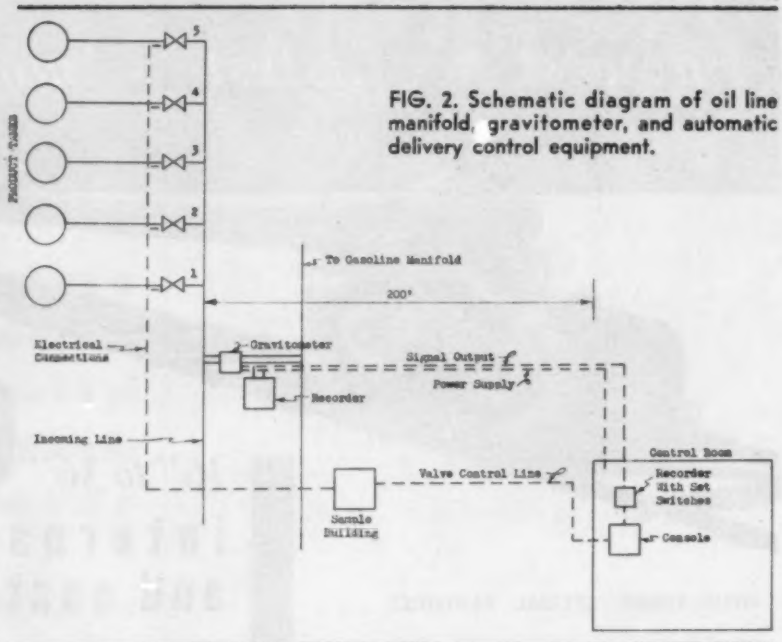


FIG. 2. Schematic diagram of oil line manifold, gravitometer, and automatic delivery control equipment.

Hartsdale Installation

The automatic product delivery equipment at Hartsdale station controls deliveries through a line that only transports oils. This line terminates at a manifold, which in turn connects to five tank lines controlled by motor operated valves (see Fig. 2). The gravitometer is located somewhat upstream from the manifold. Because it takes time for the sample to go from the sampling connection to the flowing column in the oil bath, the gravitometer has a supply line and heating coil lag of 35 sec for first indication. Another 30 sec is required for the gravitometer system to flush and produce a 90 percent change in signal. The gravitometer was located so that under normal flow rates the time required for the oil in the incoming line to travel from the sampling point to the tank manifold was equal to the gravitometer lag. With this arrangement, the gravitometer indicates the actual product gravity in the tank manifold.

The gravitometer is also connected to an incoming gasoline line that parallels the oil line. At present, the instrument only monitors this line, when the incoming oil line is not in operation, and cannot make automatic deliveries. Definite plans have been made to install automatic delivery equipment on this line. A separate gravitometer also has been installed recently for the monitoring of one of the station's outgoing streams.

The 0-2.5-mv output of the gravitometer is fed to an 11-in. recorder in the immediate vicinity (see Fig. 3 and 4) and a 5-in. recorder in the control room approximately 200 ft away (see Fig. 5 and 6). The recorder in the control room was restricted to 5 in. because of space limitations. The 11-in. recorder was installed to obtain a very accurate record of the gravitometer performance and to help determine whether the 200-ft line from the gravitometer to the 5-in. recorder affected the accuracy of the signal to this recorder. The 5-in. recorder gives a continuous control room record of the gravity and also is used to make the gravity setting at which the automatic delivery will be made.

Simple Electrical Circuit

Electrical circuits that actuate the proper valves during automatic deliveries are comparatively simple. Basically these circuits place another set of open and close contacts on the incoming oil valve actuators. These contacts are then actuated by a relay that is energized by a switch in the 5-in. recorder. The gravity at which this switch operates is set by turning a knob

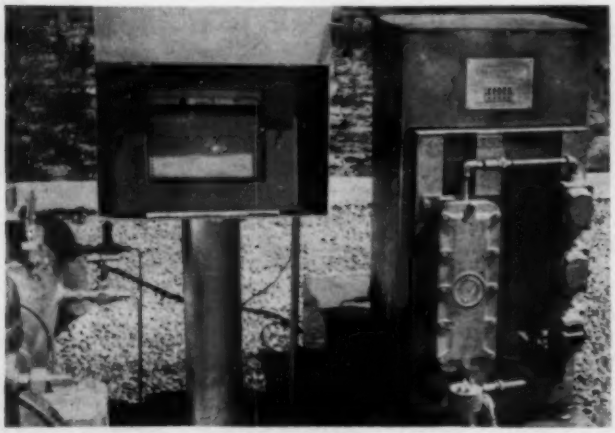


FIG. 3. Gravitometer and 11-in. recorder.

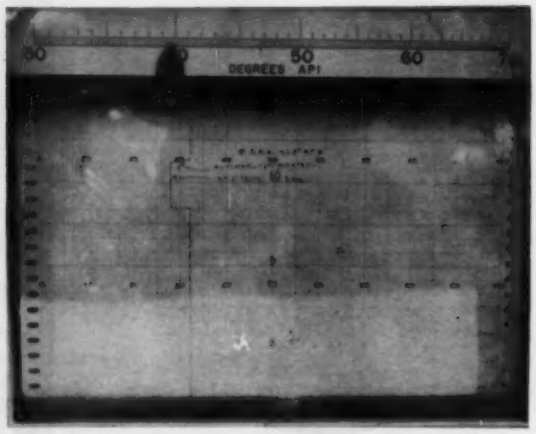
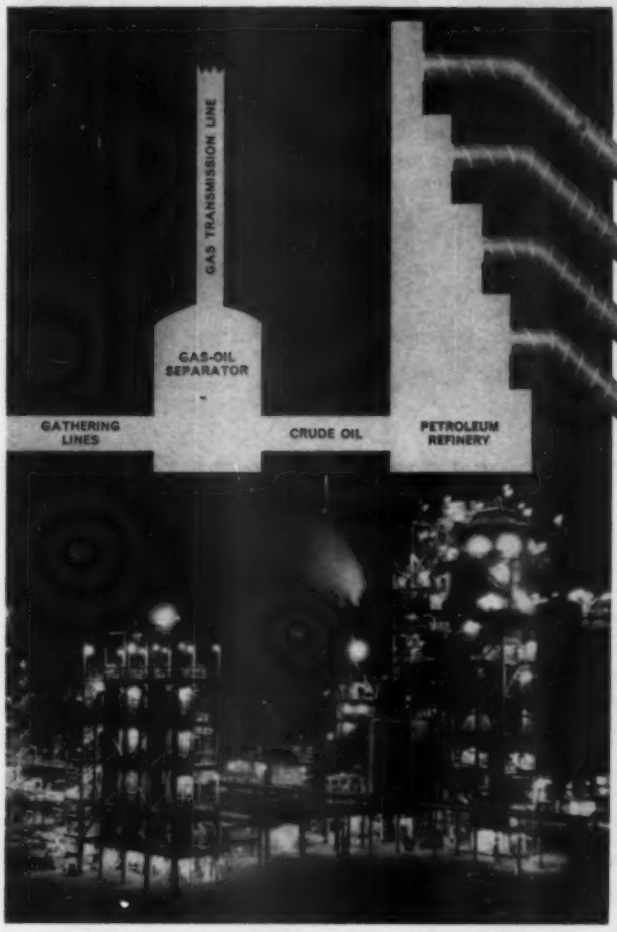


FIG. 4. Closeup of 11-in. recorder.

Polyken tape protects products lines

for this big Petro Company



Phillips pipe is cleaned and wrapped by Brodie Construction Company in a single factory-smooth operation. No primer, no drying or cooling. No fumes or fire hazards.

Another convinced user learns the money-saving versatility of one of the world's incredibly tough tapes

Phillips Petroleum Company chose Polyken No. 960 Extra-Strength Pipeline Tape to protect its products lines. This is why:

- Polyken 960 is a *dependable* pipeline coating. It is easy to handle, simple to apply, resulting in a reliable, quality installation.
- It is *especially* suited to construction of short lines and close work, as on these pipelines carrying crude oil fractions.
- It utilizes high-density polyethylene for maximum durability and corrosion resistance.
- It stands up under tough conditions of terrain and climate—experience-proved in many, many thousands of squares installed throughout the world, in plains, deserts, mountains, swamps.
- Its cathodic protection requirements are low.

AND . . .

- It saves money: Polyken 960 goes on fast with less men per job, covers more miles per day. Less equipment, less handling costs. More savings over the old hot dope idea.

See your Polyken Man . . . call your Polyken Tape Coating Distributor . . . or write Polyken, 309 West Jackson Blvd., Chicago 6, Illinois.

©1960 The Kendall Company

Polyken®

EXPERIENCED IN PROTECTIVE COATINGS

THE KENDALL COMPANY
Polyken Sales Division

FIG. 5. Automatic delivery console and 5-in. recorder with set point switch.

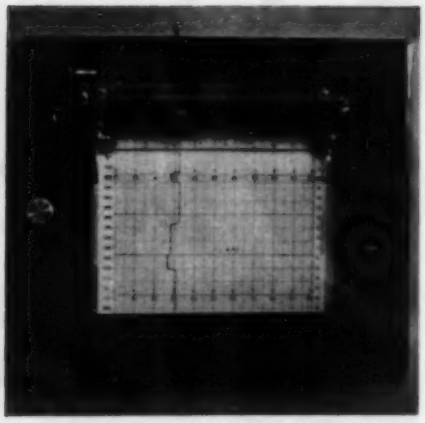


FIG. 6. Closeup of 5-in. recorder.

in the front of the 5-in. recorder. This knob sets the cam that operates the switch and moves an indicator along a scale to show the selected gravity that will actuate the switch. A console immediately above the 5-in. recorder has the necessary selector switches and indicating lights to: (1) Select the proper opening and closing valves, (2) give adequate visual indication that proper settings have been made and that the valves are operating properly, and (3) provide override protection so that if a malfunction occurs, the valves can be operated from the console by conventional pushbutton operation. A simplified schematic diagram of the above electrical control circuits can be found in Fig. 7. A picture of the console and 5-in. recorder can be found in Fig. 5 and 6.

Controls Operation Easy

Because of the basic simplicity of the automatic delivery controls, it is comparatively easy to learn how to operate them. Close cooperation of all local supervisory personnel resulted in local station operating personnel making all settings except for the initial test.

Fig. 8 shows an actual recording of two automatic deliveries made during the initial testing of the system. Referring to delivery No. 4 in Fig. 8, the recorders show the interface between No. 1 fuel oil (gravity 41.2 deg API) and No. 2 fuel oil (gravity 39.7 deg API) that occurred about 2:25 p.m. There was a gravity separation of 1.5 deg API and the gravitometer was set to make an automatic delivery about midway between the gravities with a setting of 40.4 deg API. At the console, valve No. 1 (see Fig. 2), controlling the stream to the No. 1 fuel oil tank, was set too close, and valve No. 3, controlling the stream to the No. 2 fuel oil tank, was set to open when the gravity reached the desired setting of 40.4 deg API. As the interface passed, No. 1 valve closed and No. 3 valve opened simultaneously, and the indicator light on the console went "on" indicating that the automatic delivery had been executed.

Hand samples were taken during these first checks of the automatic delivery system. In all cases the automatic delivery made the switch as fast or faster than would have been made by hand. Moreover, this comparison was made with the gravitometer set at the mid-point between gravities, whereas the hand sample cut point was determined by the first indication of a gravity

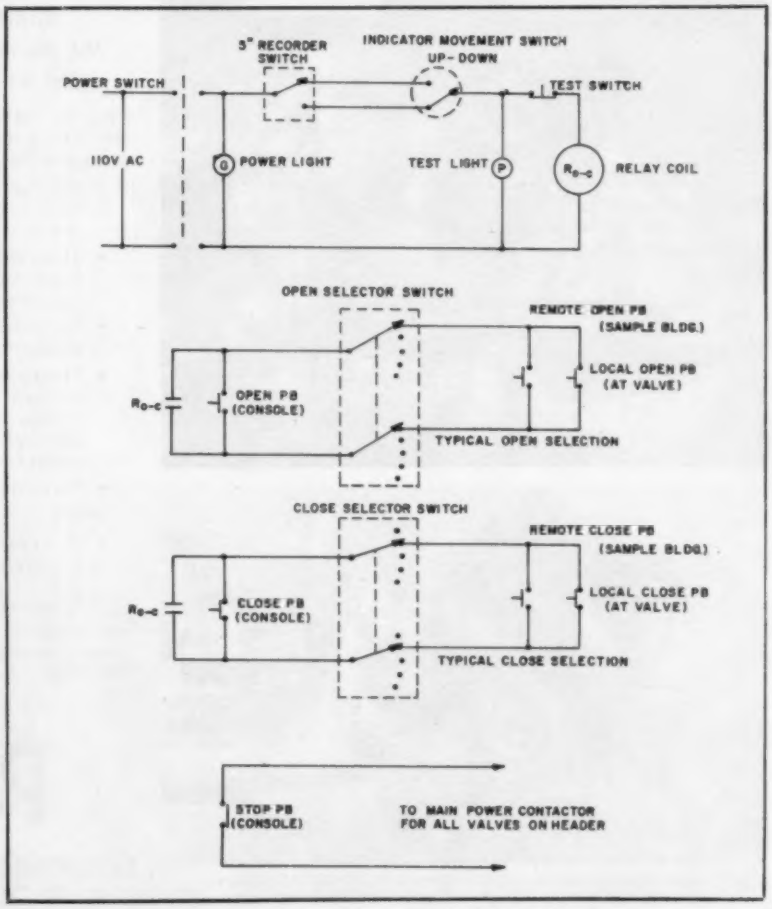
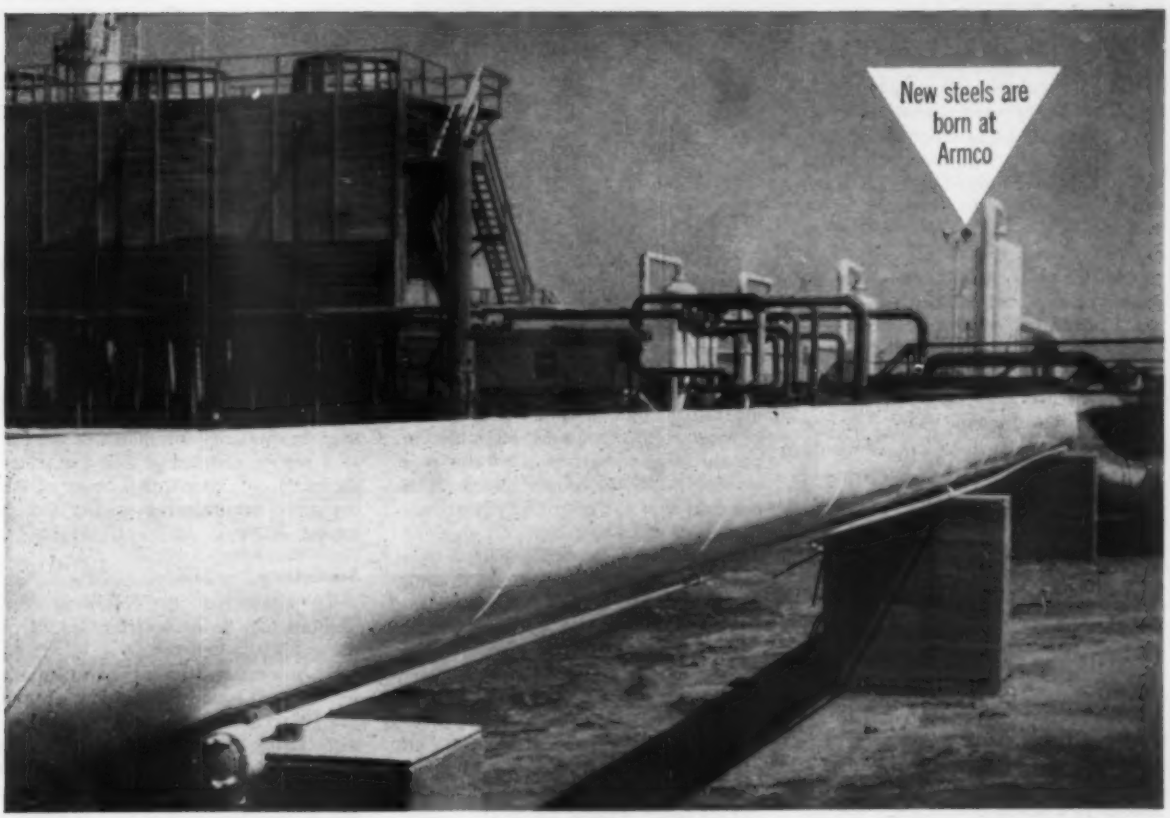


FIG. 7. Schematic of automatic gravity switching, Hartsdale station.

SPECIFY ARMCO LINE PIPE

for the strength you want in the sizes you need



Armco Line Pipe has extremely low residual stress — about 90 per cent less than in many commonly used standard pipes. This greatly reduces the danger in unforeseen overloads. Tests regularly made on Armco Line Pipe, in accordance with standard steel pipe specifications, are your assurance that Armco Pipe will meet your strength requirements every time.

You get the exact sizes you need with Armco Line Pipe because you have 132 different diameter-wall thicknesses to choose from. And because Armco Pipe is supplied in lengths up to 50 feet, there are fewer field joints, less welding and handling time.

Write us for complete information on Armco Line Pipe. Armco Drainage & Metal Products, Inc., 6520 Curtis Street, Middletown, Ohio, or 201 KOME Building, Tulsa, Oklahoma.

ARMCO DRAINAGE & METAL PRODUCTS

Subsidiary of ARMCO STEEL CORPORATION

OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company • The Armco International Corporation • Union Wire Rope Corporation

change. The set point of the gravitometer could easily have been placed closer to the "first indication" point and this would have resulted in a faster automatic cut.

In the eight months or more of testing of this automatic delivery system, it has repeatedly demonstrated its ability to: (1) Make an automatic delivery within ± 0.1 deg API of the set point, and (2) make the automatic delivery quicker than by hand sample and operation method.

A Word of Caution

Because a continuous gravity recording serves as a watch dog to all changes in gravity whatever the cause, care must be taken to prevent non-representative gravity changes from making an unwanted switch. Pumping the sump into the line, manifold changes, etc., can cause short discontinuities in gravities and if they are of sufficient magnitude can cause an unwanted switch. The only way to handle difficulties of this sort is to make a close study of the individual pipeline operations. When the causes for these non-representative gravities have been determined, the necessary corrective actions must be taken. In some cases a change in operating procedure can eliminate the trouble, in others their effects must be nullified in some manner such as introducing a time sequence in the controller circuit.

As mentioned before, the output of the gravitometer is a linear function of specific gravity. However, since the relationship between specific gravity and deg API gravity is not linear, special charts must be printed if a direct reading deg API is desired. Such a scale, although not linear, does not involve a radical change in spacing, but results in a slight convergence toward the upper end of the scale. Because of the rather small output signal of the gravitometer, care must be taken in the shielding and grounding techniques employed on the output lines. It is essential that the entire length of output signal wires be completely shielded and that the shield be connected to a solid ground at one location. Grounding the shield at more than one location usually results in a ground couple that will affect the signal output.

Results of the automatic delivery testing program have been most encouraging. The gravitometer has proved to be a reliable instrument capable of making accurate switches with small gravity differences between products. Where space permits, the use of a large recorder in the 11-in. class is recommended if the gravitometer is to be used in making automatic deliveries. It is simple geometery that the wider the chart, all other things being equal, the more accurate the gravity switch setting.

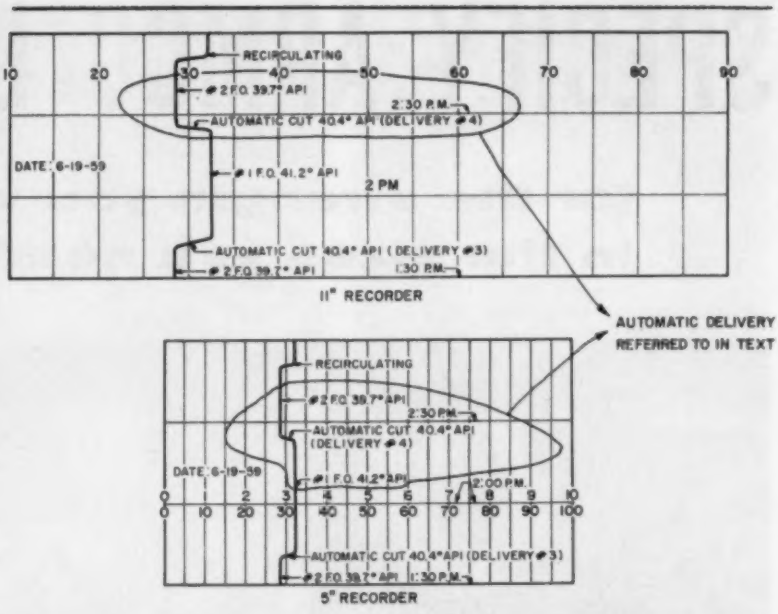


FIG. 8. Typical chart of recorded gravity of an interface during an automatic delivery.

Summary

To summarize, the following conclusions can be made from results of the automatic delivery.

1. Automatic deliveries can be made within ± 0.1 deg API of the desired gravity set point.

2. Using the 5-in. recorder as the gravity switching device, it is known that reliable automatic deliveries between products with a gravity separation of 1.5 deg API are possible. It is further indicated that reliable automatic deliveries with gravity separations as small as 1.0 deg API should be possible.

3. Considering conclusion "2" it should be possible to make automatic deliveries with gravity separations as small as 0.5 deg API with an 11-in. recorder.

4. The present automatic delivery control system is quite satisfactory. Its basic simplicity makes it easy for operators to make the necessary settings. The indicating lights make it easy to detect an error in settings before improper valve action occurs, and the override pushbutton station provides a good back-up in case of trouble.

5. "Slugs" of different gravity oil in the line can result in an unwanted automatic switch. Each pipeline should be

APPENDIX "A"

ERROR DUE TO OPERATING GRAVITOMETER BATH AT 107F VERSUS 60F

	30 deg API Sp. Gr.	70 deg. API Sp. Gr.	Sp. Gr. Difference
60F	0.8762	0.7022	0.1740
107F	0.8591	0.6802	0.1789
	50 deg API Sp. Gr.		
60F	0.7796	0.7022	0.0774
107F	0.7600	0.6802	0.0798

$$\text{At 60F \% span 50-70} = \frac{0.0774}{0.1740} \times 100 = 44.48\%$$

$$\text{At 107F \% span 50-70} = \frac{0.0798}{0.1789} \times 100 = 44.61\%$$

$$\text{Percent error} = 44.61 - 44.48 = 0.13\%$$

$$\text{Error deg API full scale} = \% \text{ error} \times \text{full scale span} = 0.13\% \times 40 \text{ deg API} = 0.50 \text{ deg API}$$

studied individually and the necessary corrective action taken to prevent such an occurrence.

6. The cost of an error by the automatic delivery system can be quite high, particularly with switches between oils and gasoline. For this reason considerable attention should be given to the installation of fail safe devices so that in the event of faulty operation of the control system no harm will be done. It is also recommended to proceed slowly toward complete dependence of the automatic delivery system. The operation of the automatic delivery system has been most reliable, but it is felt that the cost of failure can be great enough to warrant greater than normal precautions before placing complete reliance on such a system.

Henry A. Brainerd

Henry A. Brainerd has been in the Research and Development Section of the Sinclair Pipe Line Company for the past four years. Three of these years were primarily devoted to instrumentation research while on temporary duty at the Sinclair Research Laboratories in Harvey, Illinois. A mechanical engineer from the University of Delaware, he joined the Sinclair Pipe Line Company in 1952 as an engineer, senior, and participated in the construction of the Harbor Products System between New York City and Philadelphia.

Robert N. Warren

Robert N. Warren is in the Research and Development Section of the Sinclair Pipe Line Company but for the past year he has been on temporary duty at the Sinclair Research Laboratories. He holds a BS degree in mechanical engineering from the Missouri School of Mines and Metallurgy. He joined Sinclair in 1957 as engineer, junior, participating in the surveying and construction sections. For the past year and a half he has been engaged in instrumentation research for the pipeline.

* * *

handle big jobs with profits to match...

with BIG Parsons® 420 Trenchliner

SPECIFICATIONS . . . FEATURES:

trench widths — 36 to 52 inches

maximum digging depth to 7½ ft.

15 digging speeds from 15.1 in. to 25 lineal ft. per minute

double-action hydraulic rams actuate digging wheel for grading or travel

shiftable, reversible conveyor that's hydraulically driven

formed steel-plate buckets have replaceable point-type teeth — available with tine or solid backs

120 h.p. diesel engine

24-in. crawlers, tractor-type with replaceable links, pins, bushings

enclosed drive chain on crawler tracks seals out dirt

Developed especially for cross-country work, and other big trenching jobs Parsons new 420 Trenchliner® has the extra capacity needed to profitably handle your big work schedules. Digging from 36 to 52 in. wide at depths to 7½ ft., this heavy-duty wheel-type machine produces up to 25 lineal feet of trench per minute. For more facts on this big production 420 Trenchliner call Parsons distributor *now*, or write. Other Parsons wheel-types include smaller 130, 150, 170 and larger 520.

mail to: PARSONS COMPANY, NEWTON, IOWA (A Division of Koehring Co.)

Send more information on 420 Trenchliner

NAME .....

TITLE .....

COMPANY .....

STREET .....

CITY, STATE .....

P12 PE

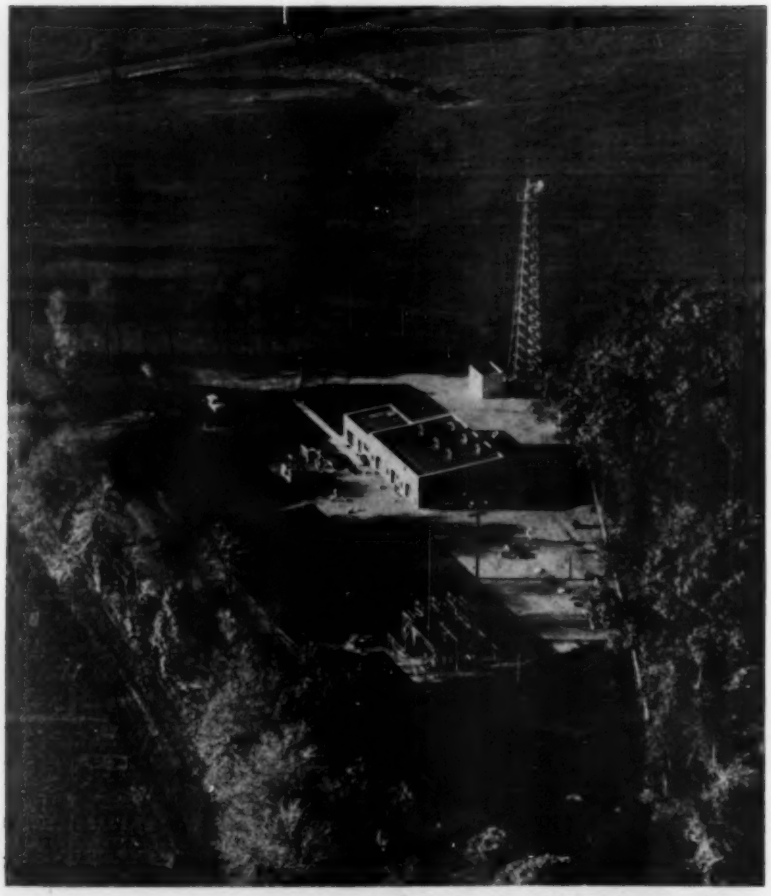
PARSONS COMPANY Division of Koehring Co.

Mfrs. of TRENCHLINERS SHAWNEE® BACKHOES, LOADERS, BLADES

First Things First in Automation

Should you automate your pipeline, and, if so, to what degree?

Harry G. Schad, *President, Atlantic Pipe Line Company*



Use of microwave has opened a completely new approach to automation.

▶ IT SEEMS every time for the past several years that I read through a pipeline trade magazine I am confronted with an article on automation. Usually, the sometimes elaborate gadgetry, the digital computers, and associated marvels are described in great detail and with almost feverish enthusiasm. We read of pipelines that are controlled completely from a metropolis 400 or 500 miles from the trade area served by the pipeline. Some of the systems described strain a practical pipeliner's imagination.

Now you might think that I am not in favor of automation. To the contrary, I am definitely an advocate for the mechanization of the job to be done, but my enthusiasm varies in direct ratio to the results obtained in dollars and cents. I firmly believe that capital money spent for automation should result in greater efficiencies and therefore, in decreased expenses, producing greater profits or permitting tariff reductions.

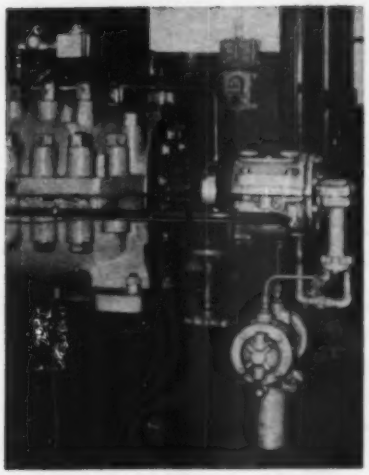
Ideal Control System

The ideal pump station control system, it seems to me, is a system in which most of the controls are at the station site and the station responds to the demands of the pipeline with a minimum of intelligence being transmitted to the main control center. Enough information must be transmitted, of course, to monitor the operation properly.

There is one area in pipeline operation where we can expect a major breakthrough. In products pipelines, particularly, the prospect of automatic accounting of receipts and deliveries captures the practical imagination. With positive displacement meters so widely used today, and with the high degree of accuracy it is possible to obtain with them, given a good communications system, the data from the terminals can be fed into a small (and relatively inexpensive) electronic computer. The records obtained would be completely current, with accounting (and, to a larger degree, dispatching) effort reduced to an absolute minimum.

Here, then is a really automatic pipeline: The pump stations respond to the instructions of the instruments, the instruments sense the needs of the pipeline to maintain a predetermined requirement, and the terminal metering data is collected, recorded, and calculated automatically.

Programming the operational requirements is completely possible, although I must admit I have not seen as yet an application that produced a return on the capital investment that was in any sense spectacular. The rate of



Mechanical seal installed on a 34 year old pump. Control of internal corrosion has enhanced use of mechanical seals.

return on investment in some of the other areas where mechanization can be applied is quite adequate.

Basic Factors that Make Automation Possible

There are other facets to this matter of automation that deserve serious consideration before an overall program is undertaken. In fact, we get so preoccupied with methods and instrumentation that we sometimes lose sight of the basic technical improvements that make automation a good business risk. Consider, for example, the subject of communications. Without the advances that have been made in this science, the transmission intelligence and the remote operation of basic units becomes a costly process indeed.

The use of microwave by pipeline companies has opened a completely new approach; it has made possible observation of performance of equipment at remote locations without increasing substantially the cost per circuit.

Consider, also, the improvement in the techniques for combatting internal corrosion. Do you remember some of the older products pipelines? Hay tanks, strainers, filters, and all the associated appurtenances, sump tanks, recycle pumps—in short, a whole pump station yard full of iron and steel. Use of oil soluble inhibitors has made much of this equipment obsolete and made possible other improvements that insure trouble-free automatic operation.

Solution of the internal corrosion problem makes the use of mechanical seals a relatively simple installation. For the same reason, the reduced wear in positive displacement meters has prolonged the period between the overhauling of the meter and contributed toward greater accuracy during the period between repairs. Without contamination of the flowing oils caused by the products of internal corrosion, complete closure of valves and plug cocks is possible and valve life is prolonged.

Better valves, better pipe, improved techniques for prevention of internal corrosion, and improved gadgetry of all types have contributed toward the pipeliner's dream: A completely automatic operation from program to invoice. *

Harry G. Schad *joined The Atlantic Refining Company organization in 1925 in the transportation department. He became manager of the traffic division of this department in 1933 and was made general manager of the transportation department in September 1941. Subsequently he was elected to the board of directors (1943) and made a vice president in 1945. Meanwhile he also had been elected a director of the Atlantic Pipe Line Company (1937) and was elevated to the presidency of that company in December 1945.*

Schad was graduated from Girard College in 1920 and received the honorary degree of LLD from Bucknell University in 1958.

Power Crane Standards Adopted

A uniform method of rating full-revolving power cranes has been adopted by the Power Crane and Shovel Association.

Wilbur L. Schield, of Schield Bantam Company, president of the association, states that this action was taken to reduce confusion and enable distributors, purchasers, and users to compare machines on a uniform and equitable basis.

The method is as follows:

1. Crawler-mounted, truck-mounted, and wheel-mounted cranes will be rated on the basis of the maximum load, in tons, at the radius selected by the manufacturer, in accordance with Commercial Standards CS90-58, Par.6.06.

2. The crane rating will be supplemented by a second group of numbers to designate the Power Crane and Shovel Association classification into which the crane falls. This identification will consist of two numbers:

a. The crane rating radius, in feet, of the maximum rated load, with base boom length, as determined under Paragraph 1.

b. The rated load (expressed in pounds divided by 100, and rounded off to the nearest whole number) at 40-ft radius, with 50-ft boom length.

3. The above values are to be based on the crane ratings in the direction of least stability, with outriggers set, if the machine is so equipped.

4. Example. Assume a truck crane rated, under Paragraph 1, with base boom length, at 40-ton at 12-ft radius and at 19,600 lb with a 50-ft boom at 40-ft radius.

As explained by E. F. Rueter, chief engineer of Unit Crane and Shovel Corporation, who was the chairman of the Association Standards Committee that developed this method, the classification would then be:

40 Ton Truck Crane (PCSA Class 12-196). The figure "12" comes from the rating radius (Par. 2-a) and the 196 from dividing 19,600 by 100 (Par. 2-b).

The standards committee of the association spent almost two years on a study of this subject and analyses of the various approaches to it. And, the association is taking steps to have the method incorporated in the U. S. Dept. of Commerce, Commercial Standards CS90-58.

May 2 Hearing Set For Transco Construction

A Federal Power Commission hearing has been scheduled for May 2 on Transcontinental Gas Pipe Line Corporation's $52,622,000 construction proposal that includes about 280 miles of pipeline looping primarily in the southern half of its system and the addition of 32,040 hp in 12 existing compressor stations mainly on the northern portion of its system.

The additional facilities are designed to increase Transco's system capacity by 130,551,000 cu ft per day

Transco also proposes facilities to connect and measure gas to be purchased from wells of Tennessee Gas Transmission Company and Zapata Offshore Company offshore Vermilion Parish, Louisiana. Consolidated with Transco's proposals were applications by the latter two companies and 20 independent natural gas producers seeking authority to sell gas to Transco from fields in Lafourche, Vermilion, St. James, Ascension, and Terrebonne parishes, Louisiana, and LaSalle and McMullen counties, Texas.

Montana Line Start Set

Construction work on a new 85-mile, 6-in. petroleum products pipeline from Helena to Great Falls, Montana, will start by June 1, according to a joint announcement by Continental Pipe Line Company and Husky Oil Company.

Continental Pipe Line Company will supervise construction and operate the new pipeline, completion of which is expected by September 1.

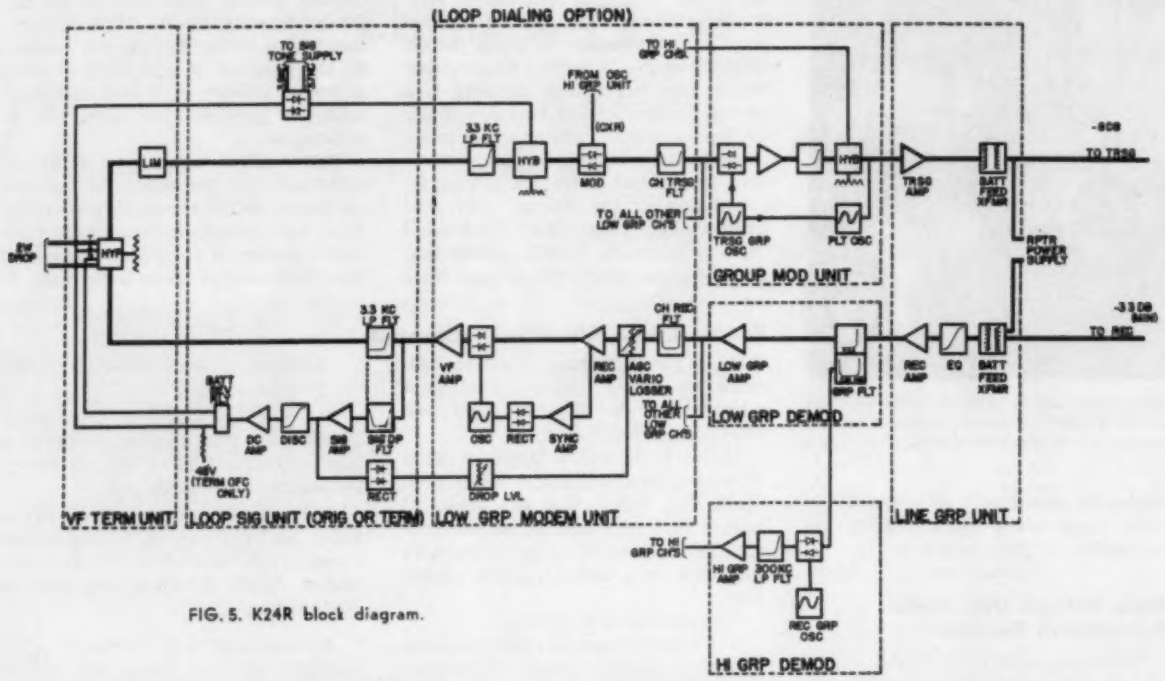


FIG. 5. K24R block diagram.

Transistorized Carrier and Multiplex Systems

PART 2 Application of the transistor in circuit design points need for re-evaluation of existing techniques

T. T. Wagner, Jr., *I.T.T.-Kellogg*

Block diagram. Fig. 5 shows a block diagram of the K24R. Voice frequency signals are accepted by the terminal equipment on a two-wire basis. The hybrid in the VF terminating unit passes the signal through the voice frequency limiter to a balanced lattice modulator in the modem unit. The balanced modulator, which is similar to that used in single sideband systems, reduces the carrier level well below the resultant sideband levels. The sidebands are applied to the group modem unit via the transmit bandpass filter.

Each modem unit includes a crystal controlled oscillator to provide carrier to the transmitting branch of the unit and to the same numbered modem unit in the same terminal. Being crystal controlled, the oscillator has more than adequate frequency stability for this application.

Outputs of the 24 channels are combined and applied to the group modem unit. Here one group is amplified and applied directly to the line. The second group is modulated below the first group in frequency by a group modulator powered by an oscillator with a frequency of 536 kc (east to west) or 552 kc (west to east).

In the receive portion of the terminal the input signal is equalized and amplified in the line group unit before it is applied to the receive amplifier unit. A bandpass, high-pass filter separates the two groups so that the low group may be amplified and applied directly to the appropriate channel modem units while the high group is modulated to low group frequencies, amplified, and then applied to its respective modem unit.

The receive section of the modem unit consists of six basic elements; namely, a channel bandpass filter, a variolosser controlled by the level of the received frequency shift signal in the signaling units, a carrier amplifier, a local oscillator, a ring demodulator, and a voice frequency amplifier.

Frequencies of adjacent channels are sufficiently reduced, after passing through the receive channel bandpass filter, to virtually eliminate crosstalk and interference from other channels. The wanted incoming signal then passes through a variolosser whose loss is controlled by the level of the signaling tone as received at the output of

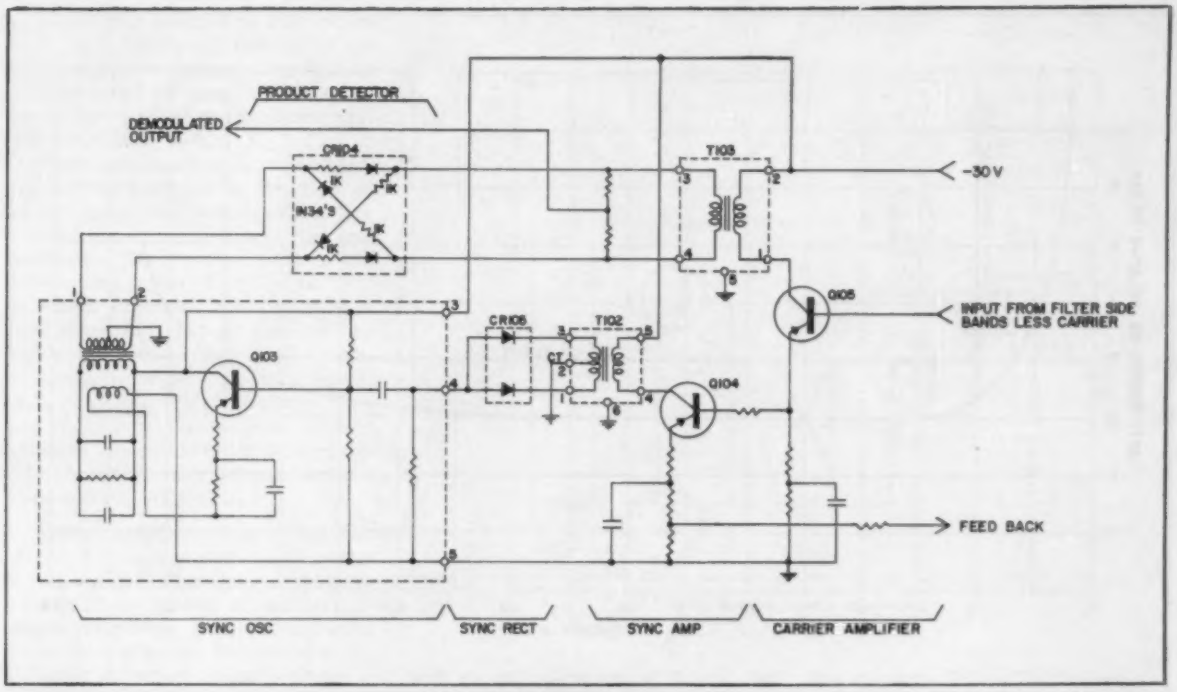


FIG. 6. Synchronous detector schematic.

receive signaling amplifier in the signaling unit of the same channel. Output of the variolosser is nearly constant regardless of the level of the incoming signals (within the capabilities of the system). The signal then passes through a high gain carrier frequency amplifier before being applied to the ring demodulator. A portion of the output of the carrier amplifier also is amplified by the synchronizing amplifier, rectified and used to synchronize the local carrier frequency oscillator. Output of this oscillator is then applied to the ring demodulator at a relatively high level as the carrier or gating signal. The resultant voice frequency signal is amplified again and before being passed on to the receive section of the associated signaling unit.

Synchronous detection circuit. In Fig. 6, a schematic diagram of the unique synchronous detection circuit is shown. Ability of the receiver to detect double-sideband suppressed-carrier AM signals is due to a synchronizing circuit that controls the local oscillator. With the synchronizing circuit disabled, the unit resembles a conventional single-sideband demodulator. For the reception of double-sideband suppressed-carrier AM signals, the synchronizing circuit detects the zero crossings of the double-sideband channel signal. These occur at twice the suppressed-carrier rate, with perturbation at a rate equal to twice the modulating frequency. The local oscillator synchronizes at alternate impulses provided by the synchronizer and ignores the perturbing impulses due to modulation. The result is a local oscillator source, synchronized rigidly in both frequency and phase, which therefore makes possible coherent detection of the double-sideband suppressed-carrier signal with fidelity. To the extent that a carrier is present in the received double-sideband signal, it is detected as d-c and can be used for control purposes.

The remainder of the voice transmission path is fairly conventional. In the signaling unit a high-pass low-pass filter removes the signaling tone from the voice band. In the voice frequency terminating unit the signal is attenuated 3 db by a pad and then is combined with the other direction of transmission by the hybrid. The 3 db pad is used when a circuit equivalent of approximately −3 db is used. If approximately zero loss equivalent is required the pad is strapped out. The hybrid is a coil-type designed to provide a stable drop impedance. A compromise net is provided; however, connections are also provided so that external precision balancing or building-out networks may be used if required.

Conditions may dictate a sonad. The K24R system will, in itself, provide high-quality, low-noise voice circuits without use of compandors or similar noise-reducing devices. As mentioned previously, however, radio link conditions may dictate the use of a sonad. The sonad subassembly, which can be added to the VF terminating unit, is available to control this crosstalk and reduce it to tolerable limits.

In principle, the sonad adds loss to the transmission circuit during the silent intervals of speech but permits normal

Wagner attended the University of Pittsburgh and presently is a petroleum industry communications specialist for I.T.T.-Kellogg. This responsibility mainly includes microwave and carrier system engineering.

Before joining the I.T.T.-Kellogg organization, he was employed by IBM and Philco in various engineering capacities. Several of his technical articles have appeared in other publications.

His military service duties were performed as a member of the Army Security Agency.

He resides in Dallas, Texas, and maintains offices in the I.T.T.-Kellogg Building.

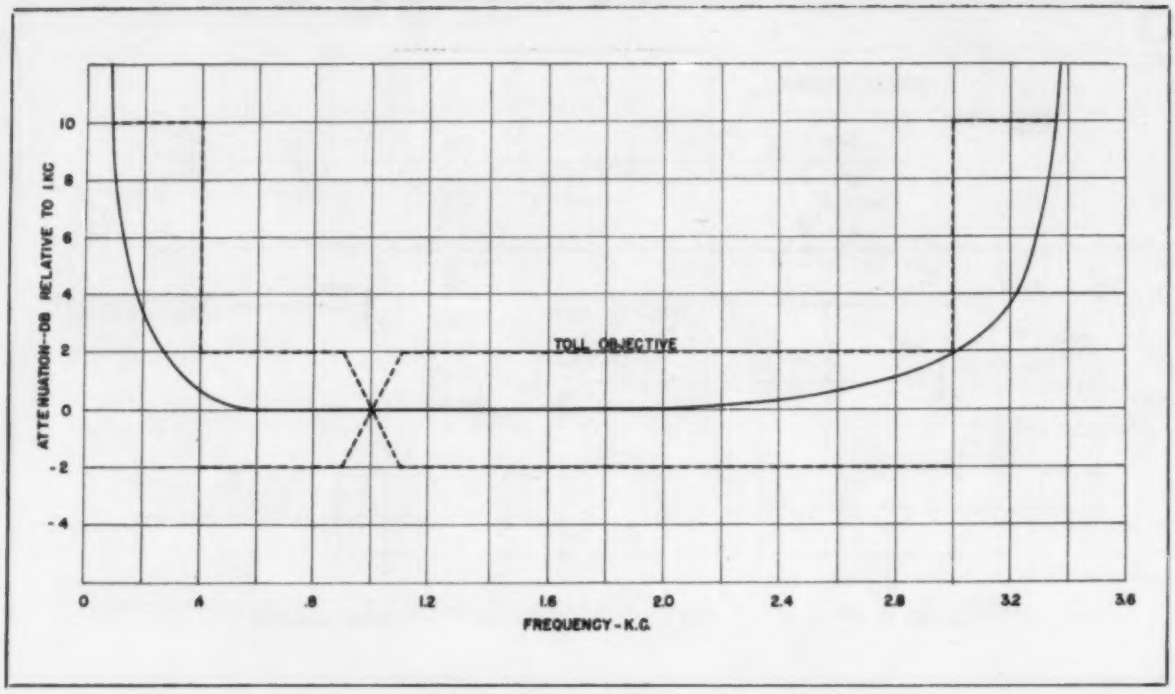


FIG. 7. Channel frequency vs attentuation curve.

speech volumes to be transmitted without loss. This is accomplished by a solid state switching circuit that adds 15 db loss to the circuit but removes this loss when the circuit is used for speech transmission. The time constants of the switching circuit are so selected that thump and other undesirable characteristics associated with similar relay type devices are drastically reduced or eliminated.

The sonad is inserted in the receive section of the channel only. It does not include a compressor. Therefore, transmission levels in the system are not increased when sonads are added as in the case when compandors are applied. Applying sonads to some channels will not increase the crosstalk in the system between those channels and others that are not equipped with sonads.

Transmitting signaling information. Transmission of signaling information from one terminal to the other for all the signaling options is accomplished in essentially the same manner. The signaling carrier supply in each terminal feeds 3.7 and 3.9 kc frequencies to each channel position. Changing the d-c condition on the "M" lead causes one frequency to fade out and the other to fade in. The shift is achieved by means of a diode switch with a fade in-and-out characteristic so as to hold fortuitous distortion to acceptable limits. Signaling tones are coupled to the voice transmission path through a hybrid and are modulated and transmitted to the far terminal in the same way as message information.

The receive section of the signaling units is of the conventional discriminator type, which serves the dual purpose of driving the signaling relay to provide the required "E" lead condition and furnishing a d-c signal for the channel regulator circuit.

In the E and M signaling version, which is the simplest type, the "E" and the "M" leads are brought out for connection to external equipment. In the loop dialing and revertive pulsing versions, additional circuitry is included at both ends to convert the E and M signaling to open and closed signaling conditions on the two-wire drop pair.

In the one-way loop dialing with reverse battery supervision method of signaling, only two signaling conditions must be transmitted in each direction as with E and M signaling. In the revertive signaling option, however, three signaling conditions must be transmitted in the terminating to originating direction. To indicate the third function both signaling tones are transmitted simultaneously. They are used to indicate the reverse battery function. This signaling condition exists for only a short interval during the dialing sequence and hence the channel regulation, which is a function of the level of the signal tone, is not materially affected.

Oscillators crystal controlled. The oscillators that supply the channel modulators and group modulators, and the pilot oscillators are all crystal controlled, providing excellent frequency stability. Oscillators in the receive section of the channel units are of the LC type. When the system is in operation they are held to exact phase and frequency with respect to the incoming sidebands by the synchronizing circuit. Components of the common signaling oscillator, which are also of the LC type, are temperature-compensated.

The same stable, medium-power, constant voltage carrier supply oscillator is used in the transmit section of the modem units, group modulator unit, and the group demodulator unit. The circuit is a modified Colpitts crystal oscillator directly coupled to a boot strap amplifier. A simplified circuit is shown in Fig. 8.

The use of a boot strap buffer provides a device with a very high impedance lead for the crystal oscillator, a very low output impedance that permits driving multiple loads with extremely low coupling, and good power gain and overload characteristics. The resultant carrier supply is capable of 20-24 milliwatts of output power with a source impedance of a few ohms.

Because of the cost and size of low-frequency crystals, and the inflexibility of crystal oscillators, a stable LC circuit is used in the signaling carrier supply units and the receive section of the channel modem unit. A tuned collector-emitter feedback circuit is used.

The oscillator operates at frequencies of 3.7 kc to 252 kc and, without the aid of a buffer, provides over 25 milliwatts of power with a frequency stability of better than 0.1 percent over a temperature range of 0-60 C.

Considerations of economy in filtering are all important in this type of carrier equipment, particularly at the channel modem level where they are numerous. The structure used in the K24 system is that of an IF-type filter in which universal coil construction and adjustable leakage coupling are used to achieve the elements of a mesh.

Simplicity of the receive filters results in relatively low selectivity. This can be tolerated because both adjacent channels are demodulated out-of-band with the synchronous detection method used in the K24R system.

Alarm equipment detects failures. Alarm facilities are provided in the K24R terminal. The equipment detects failures of components or facilities that might cause large groups of channels to fail all at one time. No provision for detecting individual channel failures is provided because this would not be economical in a carrier system of this type.

The alarm relay is actuated by any one of the following conditions: (a) A significant change in the voltage of either the d-c supply or the output of the power supply regulator; (b) loss of reception of the system pilot from the far terminal, and (c) failure of the AGC loops in all 12 of the low group or the high group channels.

An automatic disconnect feature is inherent in the operating characteristics of the system. This will provide protection against tying up a large percentage of dial facilities if a system fails. For example, the signaling conditions that correspond to channel failure in the loop signaling option have no battery at the originating end and open loop at the terminating end. This assures that in the case of failure all dial equipment in use at the time of failure will be released.

Line level characteristics. The K24R System has the following line level characteristics: A 0 dbm test tone applied at the two wire drop results in a line level for each of the two sidebands of a maximum −8 dbm at the output of the terminal and the repeaters. The minimum receive level for which the system is designed is −33 dbm at the highest line frequency, 480 kc.

Signaling tones produce sidebands that are 10 db below the level of a zero level test tone and therefore appear on the line at the output of a terminal at approximately −18 dbm maximum.

This system provides voice circuits with an end-to-end loss of 0 or 3 db. A strap option on each channel unit selects the desired drop level.

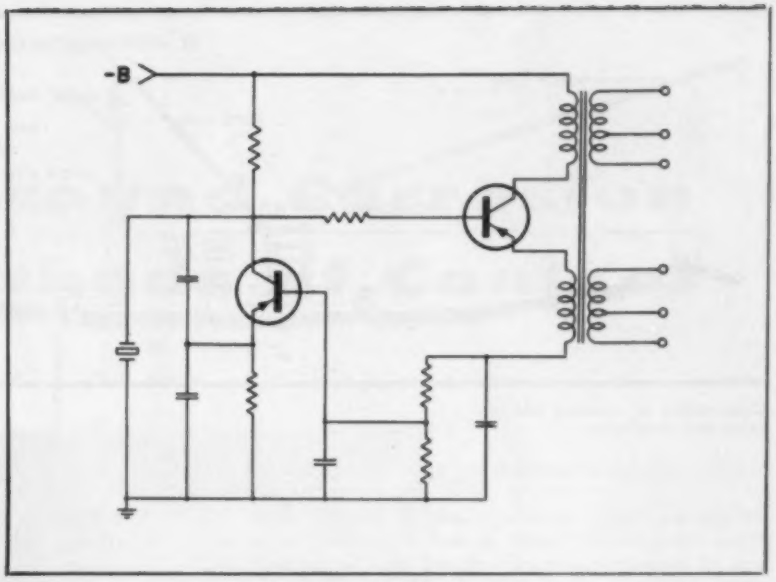


FIG. 8. Carrier supply schematic.

A fine adjustment of the receive drop level is made by means of a potentiometer in each modem unit. The −3 db drop level is intended for circuits that are not extended beyond the office where the terminals are located. The 0 db drop level is intended for use with circuits that are extended on a voice frequency basis beyond the terminating office. If other drop levels are desired in the range of approximately +2 to −5 db, they may be obtained by using the fine adjustment mentioned above.

The voice frequency terminating unit includes a high-balance four-wire terminating set. The drop impedance is available in several values. In the loop dialing, revertive pulsing and two-wire E and M signaling options, the network side of the terminating set is brought out for connection to external precision or building-out networks where needed.

Each channel includes a regulator that will reduce transmission variations of ± 8 db to variations at the drop of ±.5 db. The channel regulator uses the received level of the signaling tone as a reference.

A typical channel response is shown in Fig. 7. The 3 db points are 300 to 3200 cps approximately. The inband response between 400 and 2800 cps is flat within .5 db of the 1000 cycle loss. This exceptional channel response is possible because of the very simple channel bandpass filters required by the K24R system and because compandors are not used.

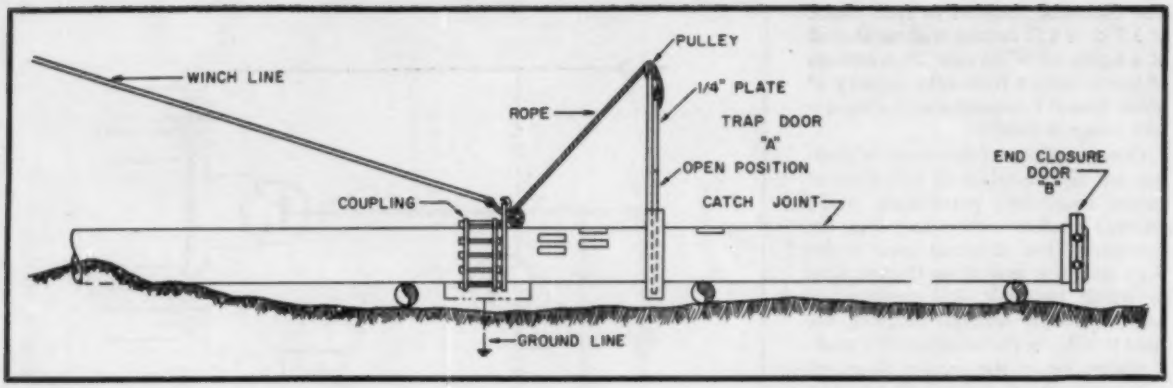
The delay distortion of the K24 system is very low—50 micro-seconds or less across the 300 to 3000 cps part of the channel band. This makes the system a very good transmission medium for data. Its excellent delay distortion characteristic is another advantage gained by using the simple channel bandpass filters. In addition, the synchronous detection method used eliminates the necessity of providing additional local oscillator locking circuitry such as is often required in a single sideband suppressed carrier system.

Further refinement of the K24R system may result in a closer channel spacing, approximately 8 kc. This would result in greater channel capacity per unit of radio link baseband. Also a possibility is the application of cross polarization techniques to the individual channels, which would double system capacity. These factors indicate that the K24R system is not limited in expansion capability.

Future Semiconductor Application

It has become apparent that the junction transistor is just the real beginning of semiconductor application and that the potential of this field is tremendous. As useful frequency ranges and power handling capacities are extended these devices promise to invade many new fields. New varieties and types of transistor manufacture appear almost to be announced daily.

The tunnel diode, solid state maser, and other discoveries each opens up new design horizons. As operational circuitry for these devices is perfected, carrier and multiplex system design may be expected to attain further perfection. ★ ★ ★



Cross-section of receiving end of catch joint installation.

A pig has just arrived in the receiving end of the catch joint.

Special Catch Joint for Off-Stream Line Cleaning

A SPECIAL catch joint designed and employed by Panhandle Eastern Pipe Line Company field personnel presents a safe and speedy means for removing pigs during off-stream line cleaning.

This special catch joint by employing two quick opening and closing gates permits blanking off the arriving pig and allows its easy removal without disengaging the entire catch joint apparatus. This eliminates time consuming catch joint handling. It also reduces the hazards of working in a gas atmosphere, which is constantly present at the receiving end of a gas line cleaning operation.

The catch joint is attached to the line at the point selected for receiving the cleaners either by welding or coupling on to the open end. If the joint is coupled, then all bolts should be installed with the coupling. An added measure of welding the follower on the catch joint is further insurance for better attachment. It is also advisable to anchor the joint with a winch cable from an available tractor or truck.

After the catch joint has been attached securely, it is then made ready for the pig runs.

Trap door "A" operated by a lanyard is set in the open position — door up. The end closure, door "B" employing hinges and two bolts is set in the close position. As soon as the pig arrives in the joint the trap door lanyard is released and the door falls shut blanking off the pig between the trap door and the end closure door.

The trap door, being closed, causes the propelling gas pressure to release upstream through the slotted openings provided for its release.

After the pressure is released, a tarp is then placed over the slots and the end closure gate opened. A rod with hook is then extended into the compartment and attached to the pig. This rod, in turn, is attached to a cable or chain of a truck or tractor which pulls the pig from within the compartment.

The pig, once removed, is hauled off for cleaning. The end closure gate "B" is then repositioned to the closed position with the two bolts and the trap door lifted to the open position for another pig run. ★ ★ ★

Underground Corrosion and Methods of Control

PART 4

O. C. Mudd, *Consulting Engineer, Alpine, Texas*

ELECTRICAL INSULATION HAVING LOW MOISTURE PENETRATION

Electrical insulation between metal surface and soil is a requisite to preventing electrochemical action. Materials used for insulation have extremely high resistances and these resistances vary between materials, even between lots of the same product.

All organic insulating materials allow some degree of moisture penetration from one face of the material to the opposite face and this is termed the Moisture-Vapor Transmission rate (M.V.T. rate), not to be confused with moisture absorption. Some materials allow moisture transmission while they absorb very little, others absorb appreciable amounts in the surface exposed to moisture while very little is transmitted through to the opposite surface.

The first property is illustrated where fruit packers place dried fruit in plastic bags and then store them until the contents acquire enough moisture through the plastic film to swell the contents to a tight fit, yet the film shows little moisture gain.

The reverse characteristics have been observed in coating materials during a five-year test where the outer surfaces absorbed considerable moisture but there was little evidence of transmission to the opposite face. This absorption appears to cause molecular compression within the material and transmission is curtailed.

Moisture penetration rate is related to coating resistance decline.

Water soluble chemicals included in any coating will cause a decline of resistance, hence it is advisable before purchasing to ascertain the maximum content of such chemicals allowed in the product. Test results indicate that a content of more than 2 grams per ton can cause a rapid rate of resistance decline in some coating materials.

From the above it is evident that the factor of good initial plus sustained electrical insulating properties are most important for effective underground coatings, and true eventual coating cost is related to this sustained insulating property.

Tape type coatings applied over viscous materials that include no solvents would help eliminate air inclusions, thus reducing the chances of moisture migration to the metal, and particularly if this material bonds well to the metal surface and solidifies to a degree that resists displacement by external pressure.

RESISTANCE TO COLD FLOW AND PENETRATION

Coating materials are subjected to possible deformation or displacement by light pressure over long periods of time. This property is known as "cold flow." It varies among materials and types of the same material. Some materials tend to flow more readily as temperature rises, others are

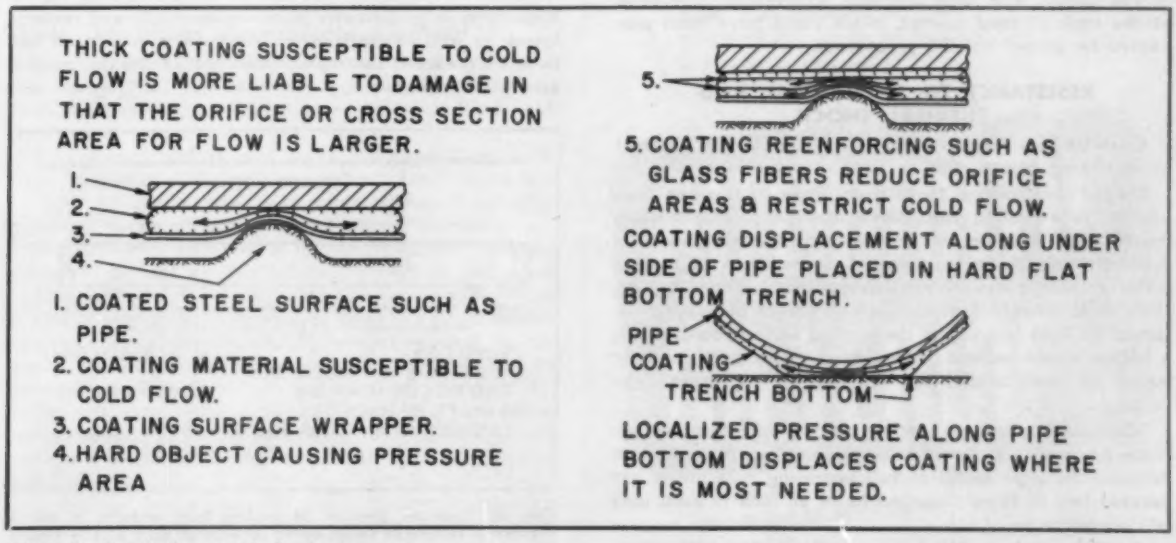

THICK COATING SUSCEPTIBLE TO COLD FLOW IS MORE LIABLE TO DAMAGE IN THAT THE ORIFICE OR CROSS SECTION AREA FOR FLOW IS LARGER.
1.
2.
3.
4.
1. COATED STEEL SURFACE SUCH AS PIPE.
2. COATING MATERIAL SUSCEPTIBLE TO COLD FLOW.
3. COATING SURFACE WRAPPER.
4. HARD OBJECT CAUSING PRESSURE AREA
5.
5. COATING REENFORCING SUCH AS GLASS FIBERS REDUCE ORIFICE AREAS & RESTRICT COLD FLOW.
COATING DISPLACEMENT ALONG UNDER SIDE OF PIPE PLACED IN HARD FLAT BOTTOM TRENCH.
PIPE
COATING
TRENCH BOTTOM
LOCALIZED PRESSURE ALONG PIPE BOTTOM DISPLACES COATING WHERE IT IS MOST NEEDED.

FIG. 9. Coating displacement by localized pressure.

less susceptible to flow until temperatures are near the material melting point.

The first type has no solidification temperature and the viscosity only increases as temperature is lowered, whereas the second type solidifies below a given temperature and is thus more resistant to displacement with limited temperature rise.

Displacement often results in penetrations and thus impairs coating effectiveness. It would then appear logical to increase coating thickness to reduce the chance of complete penetration.

When coating materials of the non-solidifying type are increased in thickness the cross-sectional area for cold flow increases and such materials are slowly displaced from higher to lower pressure areas, or in general from pipe bottom, where it is most essential, toward the sides and top (Fig. 9).

The addition of reinforcing material to this type during application, such as glass fibers, restricts cross-sectional coating flow area and also introduces a barrier against easy penetration. Thus such reinforcement is of marked value in preserving and extending coating life.

Such reinforcement added to the solidifying type is of equal advantage in resisting penetration (Fig. 9).

Exterior wrap over hot-applied coatings also helps in restricting cold flow and is essential for coating preservation where soil formations, such as colloidal clays, strongly adhere to the coating material surface and frequently pull the coating from the pipe surface when the clay, upon loss of moisture, shrinks away from the pipe.

This exterior wrapper should be free of organic material, which is subject to decomposition in soil. Organic wrapping materials forced to the metal surface of buried pipe has caused severe corrosion.

Asbestos wrapper has given best results in the past. It is not affected by soil chemicals and few, if any, soil formations adhere to its surface. Such wrapper has no electrical insulating value after exposure to soil moisture and there is little advantage in the use of material heavier than required for satisfactory application.

Present tape type coatings are extremely thin because of cost competition and this thin material is vulnerable to penetration by hard, sharp objects, such as gravel and fractured stone. To solve this problem an outer wrap customarily is used over the tape.

Penetrations of heavy extrusion coating have been observed rarely. The most frequent occurrences have been at the ends of road casings, which could have been prevented by proper backfill procedures.

RESISTANCE TO MECHANICAL AND THERMAL SHOCK

Coatings may be subjected to mechanical and thermal shock during construction or later in operations.

During construction, particularly when coating has been applied in a coating yard, there may be occasions when coated pipe is subjected to severe mechanical shock by careless handling or by accident. Some types of coating suffer complete loss of bond to the metal while showing little or no surface damage. Such severence of bond is detected by light tapping on the coating surface, resulting in a hollow sound instead of the characteristic solid metallic sound of well-bonded hot applied or extrusion type coatings.

Mechanical shock to coatings during operation has become an important factor in large diameter thin-wall pipe because the pipe metal at full operating pressure is expanded two to three thousandths of an inch in each inch of circumference.

A sudden station shut down, as often occurs with power failure, results in sudden contraction of the pipe, and if a coating material, at low winter temperatures, does not contract with the pipe the bond between pipe and coating will be severed. Also, the reverse may occur when operating pressure is rapidly applied to a cold line — the coating may fracture along the pipe. These results can seriously impair a good coating, hence it is economical to apply materials having the resilience to stay with the pipe metal under these sudden changes.

Thermal shock during construction may occur through sudden weather changes, causing coating cracks or loss of bond, and occasions may arise in operation when sudden change in the temperature of the transported commodity may damage the coating.

Most currently used tape type coatings have resilience enough at low temperatures to stay with the pipe metal during mechanical or thermal shock.

EFFECTIVE COATING BOND TO METAL

Coating bond to the metal surface plus the continued retention of this bond is most important. A good bond keeps the coating in place, thus helping to restrict cold flow.

The most important factor is in the prevention of voids between coating and pipe, which accelerates moisture accumulation. This moisture starts corrosion that may continue undetected even when all present corrosion prevention methods are applied.

All present practical type coatings have moisture penetration rates, some are relatively low but even those having low rates will accumulate moisture in voids with time and this usually extends into many years. It is thus apparent that adequate and continuous coating bond, eliminating voids between coating and metal, will provide a more effective coating.

MEASURES THAT INSURE COATING PRESERVATION

Many excellent coating applications have suffered serious impairment during placement, backfilling, and by subsequent settling of the backfill.

Applied coating is an investment and this investment is made with the intent of conserving the larger investment in the buried structure. Coating damage thus becomes a waste unless the measures to prevent such damage exceed the cost of supplemental protective measures plus cost of future structure repair and loss of revenue during repair. Repairs on large diameter pipelines are costly and revenue losses, as well as customer delivery curtailment, can add to or even exceed the replacement cost of the line section excavated for repair.

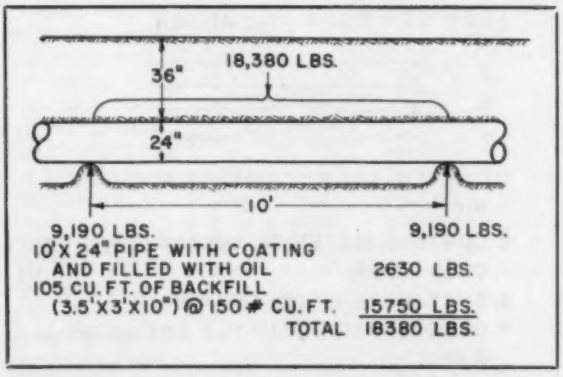


FIG. 10. Localized pressure on coating from bridging in trench. Illustrating calculated forces acting on a 24-in. diam pipe in a 42-in. wide trench with 36-in. cover.

Much coating damage during and after placement has been due to negligence in educating those associated with construction and maintenance regarding the limitations within which the applied coating can be preserved.

Most hot-applied coating suffers rapid displacement when external pressures against them exceed 10 psi, and it is preferable to have less than this pressure.

The total weight for each lineal foot of a loaded 24-in. OD pipe filled with 36 deg API crude oil is as follows:

Pipe weight	95 lb per ft
Coating weight	3 lb per ft
Oil weight	165 lb per ft
TOTAL WEIGHT	263 lb per ft

The circumference of a 24-in. pipe including coating is about 76 in. The area of support for fractions of the circumference for each lineal foot and the external pressure against the coated surface for each of these fractions are as follows:

		Area, sq in.	Pressure, psi
1/8 of circumference	(9.5 in.)	114	2.3
1/16 of circumference	(4.25 in.)	57	4.6

The above pressures apply only when support is continuous and uniform and does not include the weight of backfill on top of the pipe. Three feet of backfill in a 42-in. wide trench normally will increase the weight by 1575 lb per lineal foot, thus it can be seen that one-eighth circumference support exceeds 16 psi, if the support is uniform and continuous. Thus it is obvious that every effort should be made to provide adequate area of continuous support (Fig. 10).

Coating performance is determined by actual use, hence it is important that unbiased facts from actual service be considered in choosing a good material for extensive coating projects, and new untried products confined to lesser projects to minimize the risk of replacement cost.

Coating materials can and will be improved, but knowledge of any improvement comes from the result of actual service; however, laboratory tests may be indicative of future service results.

(To be continued in an early issue)

Shell Develops Automatic Control

Development of a fully automatic control device to permit more economical and efficient operation of unattended pipeline pump stations is announced by Shell Pipe Line Corporation.

The company said the new device, the Power Level Controller, is capable of maintaining, without outside assistance, the optimum power level of a pumping station for most economical pumping of any predetermined volume.

The controller provides a useful alternative to other systems of pipeline automation, Shell Pipe Line said, since it can perform most of the same functions accomplished by more elaborate methods and yet requires a much smaller capital outlay. Expensive communication systems, for instance, are unnecessary because the device is installed at each individual pump station and operates independently.

The new controller's ability to function automatically and independently, the announcement said, eliminates such common weaknesses of fully automated pipe station operations as vulnerability of the remote system to communications failures, faulty operation due to spurious signals on the communications system, and excessive physical burden on the central operator.

changes charts automatically!

As dependable as the law of gravity . . . saves manpower, saves money . . . utilizes, disengages, and stores as many as 40 charts in a single recorder . . . adaptable to virtually any time/date frequency . . . requires only a fraction of clock power.

Automatic Meterman, now on the assembly line, provides a method for changing any number of field or plant recorders at the *identical moment* — making it possible to automatically correlate the charts with master meter charts without multiple computations . . . *Automatic Meterman* can be used on all standard recorders using circular charts of any diameter or thickness.

U. S. Patent No. 2,926,059. Other patents pending.

AUTOMATIC METERMAN

For descriptive literature and prices, write

MAEDER-SQUIER COMPANY

BOX 5145 • DALLAS 22, TEXAS • USA

MOLE
Pipeline
Cleaner

for BETTER cleaning of
CRUDE LINES
PRODUCT LINES
NATURAL GAS LINES
FOR DETAILS WRITE
Pipeline Cleaners Co.
Fort Madison, Iowa

Pipeline Projects

Canada To Let Four Firms Export One Billion Cu Ft Of Gas Per Day To U.S.

The Canadian cabinet has made the decision that will touch off an estimated 2000 miles of pipeline construction totaling over $440,000,000. It has granted applications by two American-owned companies and two Canadian companies to export approximately 1 billion cu ft of gas per day to the U. S. — and rejected another.

Successful applicants were Alberta & Southern Gas Company, Ltd., wholly-owned subsidiary of Pacific Gas & Electric Company; Trans-Canada Pipe Lines, Ltd.; Westcoast Transmission Company, Ltd.; and Canadian-Montana Pipe Line Company, wholly-owned subsidiary of Montana Power Company. Rejected was the application of Niagara Gas Transmission, Ltd., to export 16,700,000 cu ft of gas a day into New York State. The Energy Board held its proposed prices were too low to recapture capital and other costs.

The government's decision is expected to give a substantial lift to the Canadian economy, with gas sales to

the U. S. expected to amount to $75,-500,000 by 1963 according to Energy Board estimate. The Canadian Petroleum Association said overall revenue to Canada would amount to about $1.85 billion over a 25-year period.

Trans-Canada said it would begin immediately a $39,900,000 program. James W. Kerr, president, said, "We will place firm orders for more than $10,000,000 worth of natural gas turbines, compressors, and associated station equipment within the next few days."

Alberta & Southern will deliver 458,-750,000 cu ft a day into Northern Idaho for transmission to the San Fran-

CONCO 1245
Non-Flammable Cleaner
For EFFECTIVE
Equipment Cleaning
at
. . . Pumping Stations
. . . Compressor Stations
. . . Field Installations

CONCO CHEMICAL CO.
2411 Swiss Box 63
Dallas, Texas

Spy Detector

. . . our SPY HOLIDAY DETECTORS are as near as your telephone—in fact, in emergencies our own plane assures immediate service.

Rugged equipment for dependable holiday detection on ¾" to 36" pipe . . . signal—bell, light and spark . . . unaffected by dew or frost.

Call, wire or write.

Pipeline Inspection Co., Inc.
2104 WYANDOTTE STREET • KANSAS CITY, MISSOURI

Day Phone:
BAltimore 1-6036
Night Phone:
HI 4-6745, EM 1-3824

cisco area for a 25-year period, with prices varying from an estimated 25.11 cents per Mcf in the first year of service to 27.38 cents in the fifth year.

Alberta & Southern's parent company, PG&E, still awaits approval by U. S. and California authorities to construct the $338,000,000, 1400-mile system that will permit about 415,000-000 cu ft per day of the exported gas to flow to northern California.

Trans-Canada will tap its 2300-mile cross- Canada pipeline in Manitoba and move 204,000,000 cu ft a day for 20 years to Midwestern Gas Transmission Company at Emerson, Manitoba for transmission 504 miles to Marshfield, Wisconsin. The price at the Canadian border is estimated at 30.23 cents per Mcf for the first three years and an average of 30 cents over 20 years.

Since the Alberta Oil and Gas Conservation Board and the U. S. Federal Power Commission have already approved the import of Canadian natural gas at Emerson, Trans-Canada plans to rush construction and manufacture of equipment to allow export at Emerson to begin by November 1.

Over 50 miles of 30-in. pipe will be moved to the right-of-way between Winnipeg and Emerson within a few days, and as soon as weather conditions permit heavy pipeline construction equipment will be moved to the job site. Eight new compressor stations will be constructed between now and October 31. Six of these, using natural gas turbine-driven compressors for the first time in a Canadian pipeline, will be erected in Saskatchewan and Manitoba. An engine-driven compressor station will be built at Ramore, in northern Ontario, and another will be erected near Kenora, Ontario, by the Northern Ontario Pipe Line Crown Corporation, under the supervision of Trans-Canada.

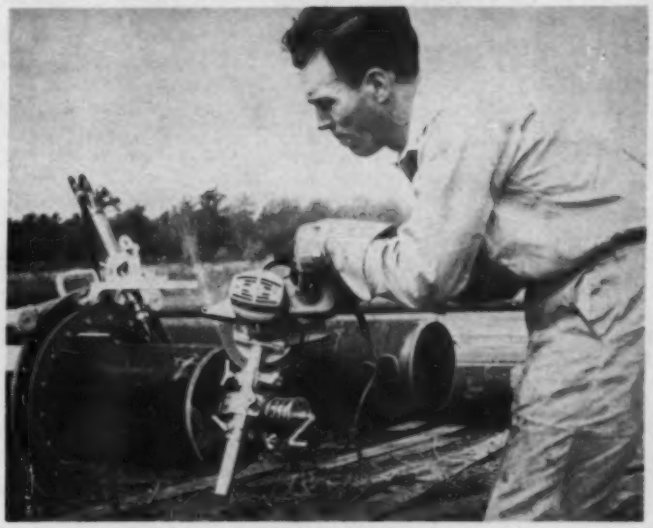
Trans-Canada also received approval to export another 204,000,000 cu ft to Tennessee Gas at the Niagara Falls boundary on an interruptible basis to the end of 1965 at 37 cents per Mcf. Export at Niagara Falls is still subject to FPC approval.

Westcoast Transmission, which is already shipping gas into the Pacific Northwest, received authority to use part of the Alberta & Southern complex to move an additional 152,000,000 cu ft a day for 20 years. It will deliver gas to El Paso Natural Gas Company at an estimated 25.66 cents per Mcf for the first year and 26.63 cents in the fifth year.

Canadian-Montana will buy gas from Alberta & Southern and sell to the parent company at Grand Falls at the rate of 36,000,000 cu ft a day for 25 years at an estimated 22.63 cents per Mcf for the first year and 24.96 cents in the fifth year.

Atlas Pipe uses new H&M "BEVEL-LAND" GRINDER

PATENT NO. 2,869,293



to recondition 4000 joints of 10-inch pipe

Atlas Pipe, Inc., of Houston was faced with the problem of reconditioning several ships' cargoes of pipe to be used on the Transwestern pipeline. Most of the pipe had badly dented ends that required severing a 2" to 4" strip and placing a new bevel and land on the pipe end. The H&M "BEVEL-LAND" GRINDER was used to clean up the pipe cuts and place a new land on the bevels. The machine eliminated time-consuming handwork and insured better quality welds by accurately placing the land on the bevel.

The new H&M "BEVEL-LAND" GRINDER uses an electric or air powered grinder to clean pipe cuts and place the land on pipe bevels. The GRINDER is available in two models — one for 6-12" pipe and one for 14-30" pipe. Larger models are available on request.

WRITE FOR THE NEW H&M CATALOG

which features the complete line of H&M Pipe Cutting and Beveling equipment.

for profitable pipe cutting and beveling
H&M STANDARD MACHINES & ACCESSORIES

The seven models of H&M Pipe Cutting and Beveling Machines are designed to handle 1½" thru 36" pipe. H&M Accessories include — the Shape Cutter — Out-of-Round — Motorized Units —Flexible Shaft—Pipe Dollies—Boxes—Clamps.

H&M

Trademark Registered

PIPE BEVELING MACHINE CO.

311 EAST THIRD ST. Diamond 3-0241

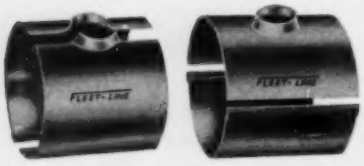
TULSA, OKLAHOMA

FLEET-LINE
WELDING FITTINGS
•
LITERATURE BY AIR MAIL...
...ask for it now.

REDUCERS: Concentric and eccentric. Nominal pipe sizes 1" to 30", ASA B16.9, ASTM A234. Schedules 10 to 160, stainless steel, and other alloys. Special lengths and sizes.

SADDLES: Conventional, and for pressure vessel heads. Nozzle sizes from ¼" to 24". Fleet-Line saddles weld neatly into place in much less time, and with much less welding rod.

Full encirclement saddles.



REDUCING TEES, Forged Steel Manifold Type.

Dealers and Stocking Distributors throughout the United States and Canada.

All orders acknowledged by air mail or long distance telephone and filled at once.

STEEL FORGINGS, Inc.

P. O. Box 276A • Shreveport, La.

Panhandle Seeks Main Line Expansion

Panhandle Eastern Pipe Line Company, seeking to expand its main line facilities and increase its gas purchases from Trunkline Gas Company, has asked the Federal Power Commission for authority to construct 330 miles of 30-in. and 38 miles of 26-in. loop; 36,700 hp in compressor stations along the proposed line; lateral line facilities; additional measuring facilities; and approximately 300 miles of 4 to 16-in. gathering lines.

Total estimated cost is $59,120,000.

Panhandle says that the proposed facilities would increase its peak day capacity by approximately 400,000,000 cu ft per day.

Railway Seeks 110-Mile Line

A $3,500,000, 110-mile pipeline has been proposed in North Dakota to transport crude oil from the Lignite and Newburg fields in Burke and Bottineau counties to Great Northern Railway's main line in the state.

Size of the Great Northern pipeline is dependent on developments occurring between now and time of construction, which is hoped to get underway this year.

Approximately 30 miles of the pipeline would be installed on GN right-of-way. A 49-mile segment would extend between Lignite and Mohall, then south for 16½ miles along GN's Sherwood branch to Forfar, junction point for the 20½-mile Newburg section. More than half of the 24-mile segment from Forfar to Minot, where the line will terminate, will be along the railway's line to the Minot Air Force Base.

GN regards the project as the first phase of an installation extending to the Twin Cities and Duluth-Superior markets.

Continues Replacements

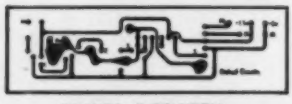
The Manufacturers Light and Heat Company, continuing its program of replacing old lines with a modern high pressure system to adequately serve the increasing requirements of eastern markets, is proposing to abandon 88.13 miles of 6-in. pipeline and 131 miles of 8-in. line located between Sideling Hill and Marietta, Pennsylvania, as well as the 700-hp Greencastle compressor station, and replace these facilities with 87 miles of new 20-in. in Franklin, Adams, Fayette, and Greene counties, Pennsylvania, at an estimated cost of $6,855,000. The company has filed an application with the Federal Power Commission.

The most effective PIPE LOCATOR in the world

FIELD PROVED
the award winning
"Signalmaster"
TRANSISTORIZED
PIPE LOCATOR
MODEL TR-1A

Utility and Construction Companies, Municipalities are unanimous in agreeing that MODEL TR-1A has proved most effective for locating mains, services, valves, conduit, high voltage lines, telephone cables. Easily separates parallel lines and can be used to trace non-metallic pipe lines. Complete piping systems traced out.

SPECIFICATIONS: Size of cases when clamped together: 9½" x 12½" x 5½" • Size of transmitter and receiver boxes, each: 9½" x 12½" x 2¾" • Operating weight, transmitter: 4½ lbs. • Operating weight, receiver: 4¾ lbs. • Circuit: Transmitter—one transistor, Receiver—six transistors • Batteries: Transmitter—4 size C flashlight cells, Receiver—4 size C flashlight cells • Switching: a. Automatic power switching for all "on-handle" operations. b. Automatic "turn-off" when set is not being used.



ETCHED CIRCUITRY

ENCAPSULATED PARTS

SEVEN TRANSISTORS

The COLDAK Company, Inc.
Leading Electronic Manufacturer
1933
1540 W. Glenoaks Blvd.
Glendale 1, California

South Texas Gas Gathering System Planned

Gulf Resources, Inc., and Natural Gas Gathering Company, Inc., have revealed plans for an outlet for natural gas reserves in the Zapata and Starr counties area of South Texas.

The companies have filed application with the Federal Power Commission for authority to sell gas to Tennessee Gas Transmission Company and plan to build a gathering system, with a capacity of 70,000,000 cu ft per day, that would deliver to Tennessee's existing facilities near the Zim field, Starr County.

Natural Gas Gathering Company, Inc., a wholly-owned subsidiary of Delhi-Taylor Oil Corporation, will operate the jointly-owned facilities under the direction of Bob J. Beard, vice president. Gulf Resources' president, C. L. Rice, will directly represent his firm's interest.

The system would consist of 31 miles of 14-in. pipe and approximately 30 miles of 12 and 10¾-in.

Seeks $16,910,000 Facilities

United Gas Pipe Line Company, proposing to purchase an estimated 120,000,000 cu ft of gas per day from Gulf Oil Corporation and Tidewater Oil Company in the Bastian Bay area of Louisiana, has filed an application with the Federal Power Commission for authority to construct and operate pipeline facilities that would cost an estimated $16,910,000.

Oil Gathering System Sold

Western Natural Gas Company has acquired from Sinclair Pipe Line Company a 246-mile crude oil system handling 4300 bbl daily taken from Brown, Coleman, Callahan, Eastland, Stephens, and Palo Pinto counties in Texas. It will be connected to the trunk line of a Western Natural division, Premier Oil Refining Company, for delivery of crude to Premier's Fort Worth refinery.

Work Starts on Long Gas Line

Construction work by H. B. Zachary Company and O. R. Burden Construction Corporation is scheduled to start in May on Old Ocean Fuel Company's $25,000,000, 370-mile gas pipeline from near the Gulf Coast south of Houston, Texas, to the Fort Worth area. Hunsaker Trucking Contractors, Inc., has been awarded a stringing contract and has set up field offices in Bryan, Waco, and Springtown.

The Texas Electric Service Company subsidiary expects gas deliveries to begin late in December. Contracts call for delivery of up to 250,000,000 cu ft of gas daily.

IDEAL BOND

The essence of pipeprotection is a perfect bond of the coatings and wrappings to the pipe and to each other.

Under Standard Specifications, your pipe is steel grit cleaned to remove all dust, mill scale and moisture and to provide many tiny facets to help bond the primer to the pipe.

1) The primer is bonded to the pipe.
2) The enamel is bonded to the primer.
3) Your wrappings are applied in a manner to assure maximum protection.

The pipe is then wrapped in kraft paper and electrically holiday detected. These processes are carried on at the exactly correct temperatures of all materials. In our storage area for wrappings, humidity is controlled to eliminate moisture.

This results in a perfectly bonded, unified coating and wrapping protection. **Ideal bond, resulting in long life for your pipe, is always obtained at Standard Pipeprotection Inc.**

standard pipeprotection inc.
3000 SOUTH BRENTWOOD BLVD. • ST. LOUIS 17, MISSOURI

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

KEEP MOVING . . . SWAMP

Sure-footed flotation saves you in soft going. Power and balance keep you rolling on steep slopes. All along the line you get money-making performance from Allis-Chalmers side boom tractors.

Allis-Chalmers' big side boom tractors have a *reputation* among pipeliners for walking right through gooey swamps that are out of bounds for other pipe layers. Long, wide tracks stay on top of mud. But it's more than just square inch of ground contact. Allis-Chalmers tractors have exactly the right combination of weight, center of gravity and clearance to stay afloat where other equipment bogs down.

They're agile climbers, too, with a combination of excellent balance and big power. From the 99-hp HD-11 to the 225-hp torque converter HD-21, Allis-Chalmers tractor engines have the deep-down lugability for steep hillside work.

Durability and safety are built in, too, with waterproof, internal-expanding side boom brakes . . . dropproof hydraulic counterweights . . . shock-absorbing,

move ahead with

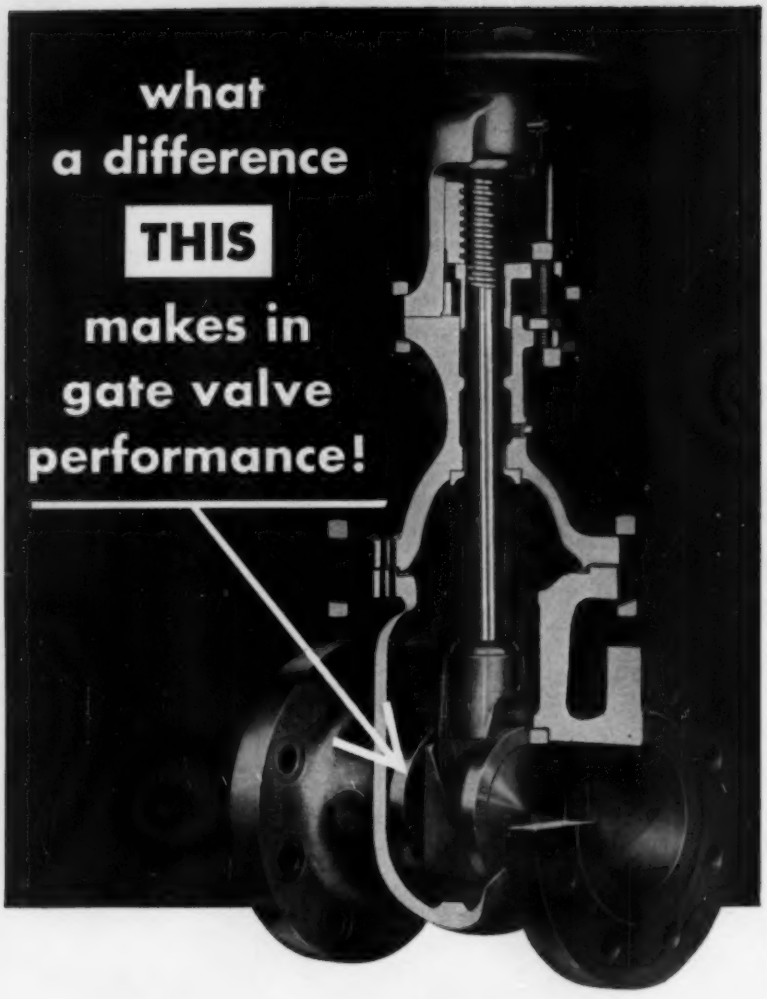
OR MOUNTAIN

all-steel tractor main frame . . . durable, double-reduction final drives . . . toughest track ever made. Certified permanent lubrication of tapered roller bearing truck wheels, idlers and support rollers eliminates greasing — saves time and cost.

Your Allis-Chalmers dealer will give you moneysaving proof why the 127,000-lb capacity HD-21, the 78,000-lb capacity HD-16, and the 40,000-lb capacity HD-11 are your best tractor buys — come swamps, mountains or biggest inch pipe. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

power for a growing world

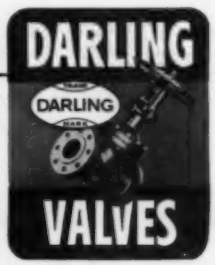


LONGER valve life, less maintenance and process interruption, positive closure, easier operation, self-adjustment for valve body deflection. These are some of the well proved advantages gained as a result of the Darling *fully revolving double disc parallel seat* principle!

These Darling valves are made in various alloys, types and sizes for most services . . . and for all pressures. Send for Catalog No. 57. You'll see what we mean by exceptional performance.

ENGINEERING SERVICE: Darling offers unusual facilities for the development and manufacture of special valves for out-of-the-ordinary requirements. This special service is available to you at all times, without obligation.

DARLING VALVE & MANUFACTURING CO.
Williamsport 2, Pa.
Manufactured in Canada by
Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.



"Budget" Authorized, Five More Filed

The Federal Power Commission has approved a $1,500,000 budget-type construction proposal by Peoples Gulf Coast Natural Gas Pipeline Company and received filings of similar applications from Transwestern Pipeline Company, Trunkline Gas Company, Kansas-Nebraska Natural Gas Company, Inc., Transcontinental Gas Pipe Line Corporation, and Columbia Gulf Transmission Company.

The FPC limited Peoples' single project costs to $375,000.

Transwestern's proposed facilities would have a total cost not to exceed $3,000,000, with the cost of single projects limited to $500,000.

Trunkline would build facilities whose total cost would not exceed $1,500,000, with cost of single projects limited to $400,000.

Kansas-Nebraska proposes to build facilities having a total cost of not more than $1,500,000, with the cost of single projects not to exceed $250,000.

Transco's proposed construction would not exceed $3,000,000, and no single project would exceed $500,000.

Columbia Gulf's construction would not exceed $2,500,000 cost, with single projects limited to $500,000.

INTERNATIONALLY . . .

The Indian Government is considering a pipeline to carry imported natural gas from Baluchistan to Bombay, via Ahmedabad. The Pakistani Government would build the connecting link to hook up with the present Sui-Karchi gas line at a point 120 miles from the seacoast.

Colombia's first natural gas pipeline—a 10-in., 140-mile line to deliver initially 20,000,000 cu ft daily to industrial consumers in the Caribbean seaport of Barranquilla — is now scheduled for completion in the latter part of 1961. It has been announced that an affiliate of Mobil International Oil Company, a division of Socony Mobil Oil Company, will join with private Colombian interests to construct the $7,000,000 line. Gas will be supplied from wells in the Cicuco field by the Colombian Petroleum Company, 50 percent owned by Mobil.

UK's first large-scale commercial products pipeline is planned—a 75-mile, 10-in. line with an initial capacity of 43,000 bbl per day, linking Esso Petroleum Company's Fawley refinery to a new 575,000-bbl depot on a 50-acre site near London Airport. Distribution would be by road over a wide area, including all west London, with special pipelines delivering aviation fuels into London Airport.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Transwestern Files For Further Facilities

Transwestern Pipeline Company has asked for Federal Power Commission authority to build additional facilities, at a total cost of $1,136,000, to attach additional gas supplies in the West Texas and Anadarko Basin areas, the Atoka field, and in Pecos County, Texas, and Chaves County, New Mexico.

Transwestern also has applied for authority to construct additional facilities, at an estimated cost of $2,452,200, to enable the company to attach an additional 40 billion cu ft per day which is contracted from United Carbon Company in Wheeler County, Texas.

Transwestern says the gas from the West Texas and Anadarko Basin areas and from the Atoka field will provide an additional 100,000,000 cu ft per day. It says that in the Pecos County and Chaves County areas there are reserves in excess of 13½ billion cu ft, of which the company already has contracted for over 6½ billion cu ft.

To Install Crude Line

A new $4,000,000 project that includes 54 miles of new pipeline and additional tankage has been revealed by The Buckeye Pipe Line Company.

The project will extend the company's 22-in. crude oil pipeline from Toledo to Samaria, Michigan, and add a 16-in. line from Samaria to refineries at Trenton and Detroit.

Certain of Buckeye's existing smaller diameter lines, which now transport crude oil to the Detroit refining area, will be converted to refined products service.

IN CANADA . . .

Surface Line-Laying Proceeds Before Thaw

Banister Construction, Ltd., has begun construction of 50 miles of crude oil gathering lines in southeastern Saskatchewan for Producers Pipelines, Ltd.

The first portion of the job, underway in April, covers 18.5 miles of surface lines connecting the East Parkman field to the existing Parkman field gathering system and tying in new batteries in the Arlington, South Manor, Hastings, and Steelman fields. Ditching and burying of the surface lines will be done after the spring thaw. Normal construction will continue as required through the summer.

Producers pioneered the winter laying of surface lines several years ago to speed up attachment of new batteries during the period of heavy development drilling in the southeastern region and to provide pipeline service during interruption of truck deliveries caused by the spring road bans in April and May. Stringing on frozen ground minimizes damage to right-of-way.

Majestic Works To Beat Ice Break-Up

Completion of right-of-way work before the spring thaw is planned by Majestic Contractors, Ltd., on two small construction jobs in north central Alberta muskeg terrain for Federated Pipe Lines, Ltd.

The first job, in the area northeast of Swan Hills, is 18 miles of 6-in. line connecting the Deer Mountain oil pool with the present pipeline terminal on the east flank of the Swan Hills field. Jeff Minter has been appointed spread superintendent.

The other consists of 14 miles of 8-in. line from the Whitecourt battery in the Carson Creek North oil field, southwest of Swan Hills, to the Louise battery on the southwest flank of the Judy Creek field straight south of Swan Hills, where the present gathering system of Federated terminates. Rusty Killingsworth is spread superintendent.

C-R-C IMCO BEVELER
handles 16 sizes of pipe

One C-R-C IMCO Pipe Beveler and cutting torch with a complete set of bands handles all sizes of pipe from 6 thru 34 inches . . . with ease and accuracy.

- Makes perfect and complete square cuts.
- Cuts out-of-round pipe without additional attachments.
- Flexible drive shaft permits safe operation.
- Fast set-up — simple operation — easy to store or transport.

For full details write or call:

SERVING PIPELINERS • SINCE 1933 •

CRC

CRUTCHER · ROLFS · CUMMINGS, INC.

Home Office: Houston, Texas, Box 2073, OVerland 6-4301

Export Office: International Oil Equipment Co., 30 Rockefeller Plaza, New York, N. Y., COlumbus 5-6250
In Canada: Canadian Equipment Sales & Service Co., Ltd., 7510 99th St., Edmonton, Alberta, Canada

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

AUTOMATION!

ARE YOU PLANNING REMOTE OPERATION OF YOUR ENGINES?

McCORD

HAS A COMPLETE LINE OF CONTROLS FOR

McCord Force Feed LUBRICATORS

VISUAL FLOW FILL CONTROL

Operates from central supply tank or engine crankcase.

Install in space of one lubricator feed. No machining or alterations necessary. Large sight feed shows make-up oil when called for by lubricator. Order part No. A31252.

LUB-SENTRY

Install in one pump space. Provision for pressure switch to shut down engine or sound alarm.

SIGNALS LOW OIL LEVEL OR MECHANICAL FAILURE

Contact your nearest McCord representative or write for catalog sheet McCord Lubricator Controls.

McCORD CORPORATION

LUBRICATOR DIVISION

DETROIT 11, MICH.

WITH THE PIPELINE CONTRACTORS

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has been awarded contract to construct for *Old Ocean Fuel Company* 184 miles of 24-in. natural gas pipeline between Washington County, Texas, and Fort Worth. Spread No. 1, consisting of 92 miles, begins at Washington County and ends at Limestone County, under the supervision of R. M. Jones. Spread No. 2, consisting of 92 miles, begins at Limestone County and ends at Fort Worth, under the supervision of C. M. Hoffman.

● **Cape Construction Company, Box 423, Cape Girardeau, Missouri.** Has been awarded a contract by *Illinois Power Company* to build approximately 22 miles of 12, 14, and 16-in. high pressure gas lines near Belleville, Illinois, where headquarters will be located under the supervision of Trece Boyd.

● **Engineers Limited Pipeline Company, 11858 San Pablo Avenue, El Cerrito, California.** Has been awarded a joint-venture contract with Pacific Pipeline Construction Company for the construction of 116 miles of 34-in. pipeline for *Pacific Lighting Gas Supply Company* between Needles and Newberry, California. Lee Erlewine is superintendent at Ludlow, California.

● **Fulghum Contracting Corporation, Box 1181, Harrisburg, Pennsylvania.** Has been awarded a contract by *Niagara Mohawk Power Corporation* to lay 122 miles of 12-in. natural gas pipeline between Watertown and Massena, New York, including six crossings involving the Black, Grass, Racquett, and Oswegatchie rivers.

● **R. H. Fulton & Company, P. O. Box 1526, Lubbock, Texas.** Has been awarded a joint contract with Houston Contracting Company and Western Pipe Line, Inc., to lay approximately 300 miles of 16, 12, and 10-in. trunk lateral lines in the Texas-Oklahoma Panhandle and West Texas-New Mexico area for *Transwestern Pipeline Company*. Has received a contract from *El Paso Natural Gas Company* for construction of 126 miles of 30-in. pipeline in various loops across New Mexico, paralleling the company's existing line, and has named H. A. Tinkler superintendent and has located the field office at Tatum, New Mexico.

● **Hood Construction Company, 8201 South Sorensen Avenue, Whittier, California.** Has in progress a joint venture with J. P. Neill Company and River Construction Corporation involving the construction of 32 miles of 36-in. pipeline between Cucamonga and Placentia, California, for *Southern California Gas Company* and *Southern Counties Gas Company*. Cecil Jernigan and Merle Tatum are supervising at Chino, California. Another joint venture with River Construction Company has been awarded by *El Paso Natural Gas Company*, involving 120 miles of 10, 12, 16, and 20-in. pipeline from Portland to Eugene, Oregon. Field offices are at Camas, Washington, and Oregon City, Oregon, under the supervision of Bill Burgess and Vernon Gehart.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Is laying approximately 166 miles of 24-in. natural gas pipeline for *Transwestern Pipeline Company* as follows: 83 miles of 24-in. from Dawn, Texas, southwest to the vicinity of Portales, New Mexico, with A. J. Slovack as superintendent, L. L. Patterson as assistant superintendent, and Ralph Axsom as field office manager, and present headquarters at Hereford, Texas; and approximately 83 miles of 24-in. from Roswell, New Mexico, northeast to the vicinity of Portales, with M. L. Thompson as superintendent, Talmadge Crabtree as assistant superintendent, and George A. Warner as field office manager, and present headquarters at Roswell.

● **Hunsaker Trucking Contractors, Inc., Box 97, Carrollton, Texas.** Has been awarded stringing contract by *Old Ocean Fuel Company* on 275 miles of 16, 20, and 24-in. natural gas pipeline between Brenham and Graham, Texas. Field offices are located in Bryan, Waco, and Springtown.

● **Latex Construction Company of Georgia, Box 12128, Atlanta, Georgia.** Has been awarded a contract to recondition for *Plantation Pipe Line Company* approximately 60 miles of 4-in. and 40 miles of 12-in. pipeline. Thomaston, Georgia, is headquarters site, and J. M. Phipps and G. H. Matlock are superintendents.

● **Majestic Contractor, Ltd., 49 Jackes Avenue, Toronto 7, Ontario, Canada.** Has received a contract from *Federated Pipe Lines, Ltd.*, to lay 14 miles of 6-in. and 18 miles of 6 through 8-in. crude oil pipeline in the Swan Hills area of Alberta, Canada, with K. B. Killingsworth supervising at Whitecourt and Jeff Minter supervising at Swan Hills.

● **Mannix Company, Ltd., 737 - 8th Avenue, S. W., Calgary, Alberta, Canada.** Is constructing a 70-mile, 3 through 6-in. Pembina oil field gathering system for *Pembina Pipeline Company, Ltd.*, with S. Steffen as superintendent at Drayton Valley, Alberta.

● **Missouri Valley Dredging Company, P. O. Box 1592, Burlington Station, Omaha 8, Nebraska.** Has been awarded a contract by *Pacific Lighting Gas Supply Company* to construct the dual 24-in. pipeline crossing of the Colorado River near Needles, California. Topock, Arizona, will be headquarters. Harold H. Hubbard and Charles E. Hobbs are superintendents.

● **J. P. Neill and Company, 522 Meadows Building, Dallas, Texas.** Has been awarded a joint contract with Hood Construction Company and River Construction Corporation to construct for *Southern California Gas Company* and *Southern Counties Gas Company* 32 miles of 36-in. gas pipeline between Cucamonga and Placentia, California.

● **Pacific Pipeline Construction Company, 1632 S. Greenwood Avenue, Montebello, California.** Has received a joint contract with Engineers Limited Pipeline Company to construct 116 miles of 34-in. pipeline for *Pacific Lighting Gas Supply Company* between Needles and Newberry, California. Field office will be located at Ludlow, California.

● **Panama, Inc., 2201 Commerce Building, Houston 2, Texas.** Is constructing approximately 60 miles of 6-in. pipeline for *Socony Mobil Oil Company, Inc.*, from Daisetta in Liberty County, Texas, to Socony's Beaumont refinery in Jefferson County, Texas. Daisetta is field office site. T. O. May is superintendent.

now . . . longer life, improved performance for pipelines, crude units . . . with Unicor

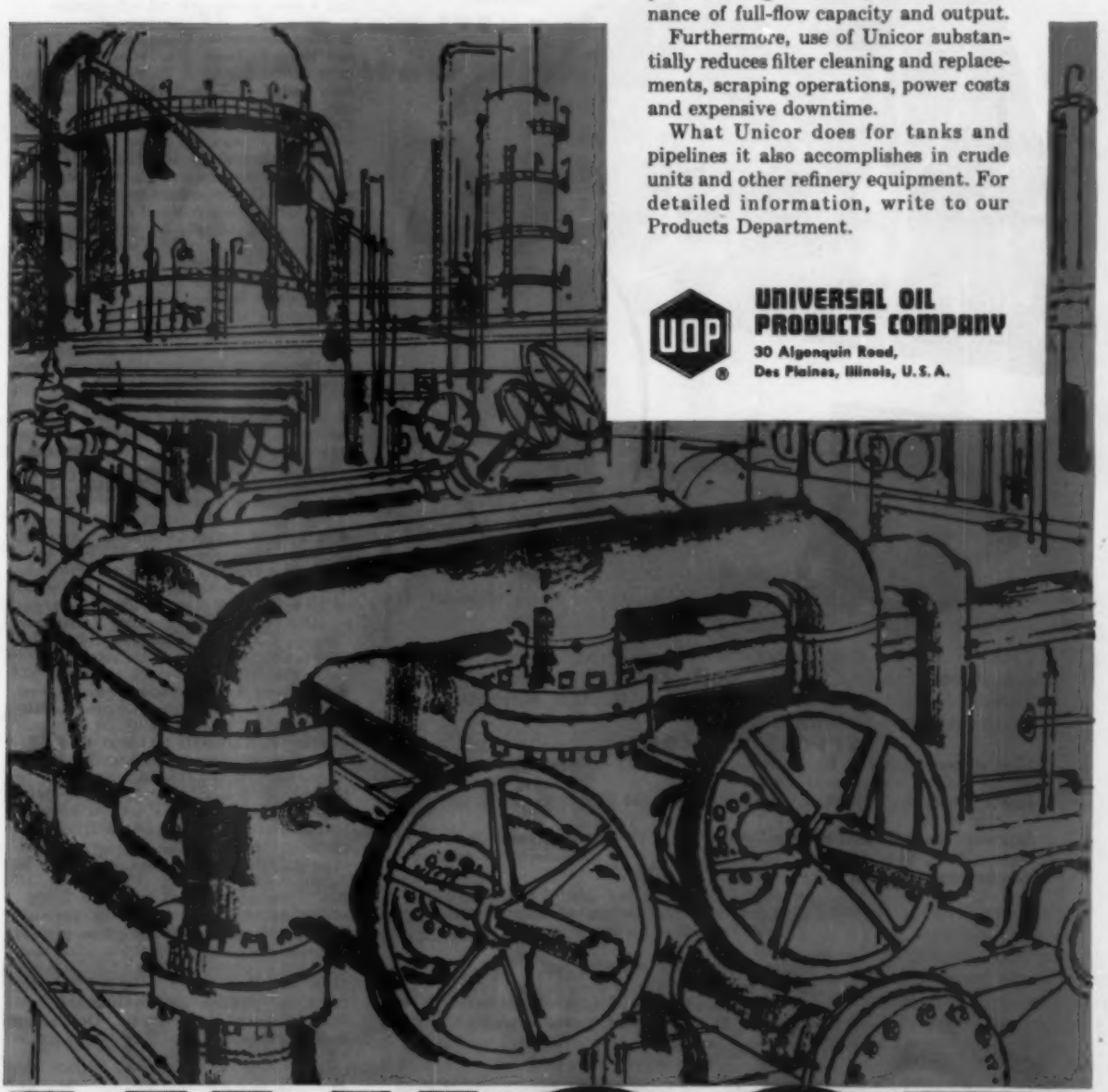
Are you aware of the tremendous difference a small amount of Unicor can make in pipelines and crude units?

This film-forming, oil-soluble inhibitor prevents all kinds of corrosion. Wherever Unicor has plated out on a surface, it gives protection to tanks, vessels and pipelines whether full, part-full or empty.

By adding a small amount of Unicor to your product—10-20 parts to a million—you prevent product contamination, profit-robbing corrosion; assure maintenance of full-flow capacity and output.

Furthermore, use of Unicor substantially reduces filter cleaning and replacements, scraping operations, power costs and expensive downtime.

What Unicor does for tanks and pipelines it also accomplishes in crude units and other refinery equipment. For detailed information, write to our Products Department.



UOP®

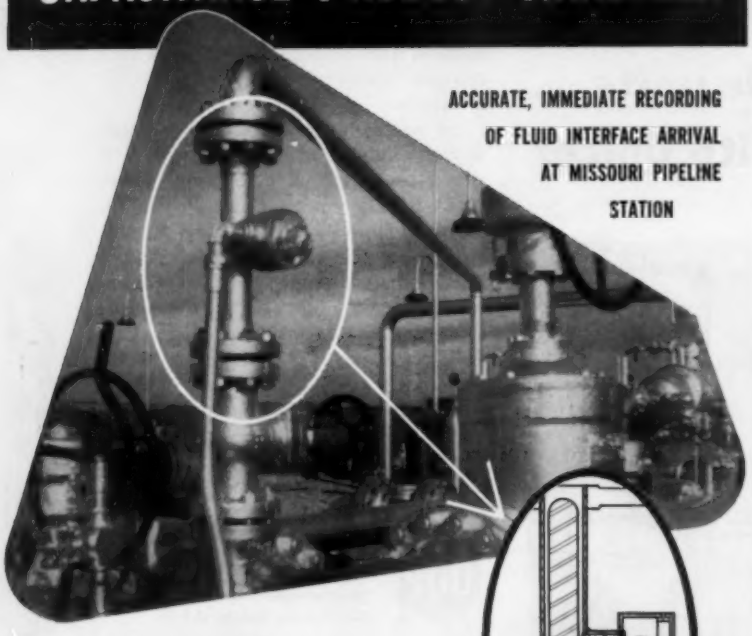
UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road,
Des Plaines, Illinois, U.S.A.

UNICOR®

BATCH INTERFACE DETECTION BY THE . . .

CAPACITANCE PRODUCT ANALYZER

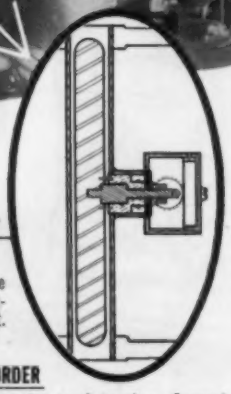


ACCURATE, IMMEDIATE RECORDING OF FLUID INTERFACE ARRIVAL AT MISSOURI PIPELINE STATION

CX-195 ▶

BY-PASS PROBE

Plastic coated. Cable connection inside explosion-proof conduit.



◀ **MODEL DLRE RECORDER**

For local recording with weather-proof housing. Connected by coaxial cable and located over 200' from probe.

CPA measures and records interface, water content or component changes in the fluid stream by measuring dielectric differences of fluid passing through a probe. Recording is on 12" round chart.

SPECIFICATIONS

Range of Measurement: 4.3 MMFD minimum and 1100 MMFD maximum (equal to 1% min. and 35% max. for water in oil)

Accuracy: Within 0.5 of 1% of actual capacitance indicated (equal to ± 0.15 of 1% water in oil)

Sensitivity: Standard — 0.043 MMFD equivalent to 0.01 of 1% water contamination in oil

Power: 115 volt, 60 cy. A.C.

Recorder Motor: Electric or spring wound

Recording: Local — at or near point of measurement; Telemetering — over any pair of telegraph grade wires; Pneumatic — provides air signal at distant point

Housing: Explosion-proof or weather-proof

Optional Accessories: High-low alarm switches; 7-day or 30-day recording charts; Temperature compensation

Probes: 2", 3" and 4" flanged, grooved or threaded

INSTRUMENTS INCORPORATED TULSA

INSTRUMENTS, INC.

BOX 556 TULSA, OKLA.

PIONEERS IN LEVEL MEASUREMENT AND CONTROL INSTRUMENTATION

● **Pipe Line Technologists, Inc., 3431 Alabama, Houston, Texas.** Has a contract to construct for *Seadrift Pipeline Corporation* a 108-mile products line from Union Carbide Corporation's Seadrift, Texas, plant to Humble Oil & Refining Company's King Ranch plant at Ella, Texas.

● **H. C. Price Company, Price Tower, Bartlesville, Oklahoma.** Has two spreads working on 336 miles of 30-in. pipeline across Arizona for *Transwestern Pipeline Company*. Spread One, supervised by G. A. "Abe" Reutzel, began construction at Window Rock and is now headquartered at Flagstaff. Spread Two under the supervision of R. L. "Bob" Ezell began at the California-Arizona border, working east, and is now headquartered at Seligman.

● **River Construction Corporation, Box 9127, Fort Worth 7, Texas.** Has been awarded a joint contract with J. P. Neill and Company and Hood Construction Company to construct for *Southern California Gas Company* and *Southern Counties Gas Company* 32 miles of 36-in. gas pipeline between Cucamonga and Placentia, California. Has been awarded a joint contract with Hood Construction Company to construct for *El Paso Natural Gas Company* 120 miles of 10, 12, 16, and 20-in. gas pipeline from Portland to Eugene, Oregon.

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has received a contract from *Transwestern Pipeline Company* to construct 325 miles of 4, 6, and 8-in. gathering lines in West Texas, Oklahoma, and New Mexico.

● **Sheppard-Geiger Construction Company Box 2098, Corpus Christi, Texas.** Has been awarded a contract by *Houston Pipe Line Company* to lay 35 miles of 18-in. gas pipeline from Sheridan to Wharton, Texas, in the Houston area.

● **Vaughn & Taylor Construction Company, Inc., Box 3266, Odessa, Texas.** Has been awarded a contract by *Emerald Corporation* to lay 54½ miles of 16-in., 5½ miles of 20-in., and 20 miles of 2 and 4-in. gas pipeline from east central Ochiltree County, Texas, to Shamrock Oil & Gas Corporation's Stewart compressor.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has been awarded a contract by the *National Iranian Oil Company* to construct a 240-mile, 8-in. petroleum products line in Iran from Rey, near Tehran, northeast to Sharud. Is laying a pipeline for *Mid-America Pipe Line Company* as follows: Spread No. 1, under Harland Evans, located at Pampa, Texas, will lay approximately 238 miles of 8 and 10-in. pipe in Texas, Oklahoma, and Kansas; Spread No. 2, under Tommy Thompson, located at Arlington, Kansas, will lay approximately 435 miles of 8 and 10-in. pipe in Kansas, Nebraska, and Iowa. Has been awarded a contract by *The Manufacturers Light and Heat Company* to lay 70 miles of 20-in. pipeline from Abbotstown to Warfordsburg, Pennsylvania. Gettysburg is field office site, and Thelmer Davis is superintendent.

● **Young and Anderson Company, Box 68, Brea, California.** Has been awarded a contract by *Southern California Gas Company* and *Southern Counties Gas Company* to build approximately 85 miles of 36-in. pipeline from Newberry to Cucamonga, California. Jack Cook and R. R. "Ronnie" Cook have been named project superintendents.

Small Transmitter Tubes Tested by New Method

Results are lower maintenance cost and increased reliability of microwave communications links

Thomas H. Briggs, *President*
Briggs Associates, Inc.
Norristown, Pennsylvania

"REVOLUTIONARY" is the description for a new approach in testing small transmitting tubes. To operators of microwave communications links this new test method provides opportunities for lowering maintenance costs and increasing equipment reliability. It is called the positive grid drive current division test.

During the last few years this test has been in development and practical use by Eitel-McCullough, Inc., specialists in production of transmitting tubes. Success of the test is demonstrated by its acceptance as part of military tube acceptance specifications for 2C39, 4X150, and 4X250 tubes.

Type 2C39 is a most important tube in many microwave transmitters, favorites for communication in the pipeline industry as well as military and emergency service equipments. Hitherto, 2C39 performance has been considered erratic. To test them has been difficult. Test sets for standard receiving tubes cannot test properly for plate current and Gm of the 2C39, and other small transmitter tubes.

Servicing personnel resort to plugging the tubes into actual transmitter cavities — often a lengthy operation and capable of causing tube breakage. Then transmitter output is noted, and it is necessary to judge whether the circuit tuning is optimum or whether the tube or some other component may be at fault.

The current division tester, a portable unit, is shown in Fig. 1. It is now available commercially, and has been developed for use in the service shop, or as part of the maintenance operator's kit. In a rugged aluminum case, it can be placed in operation rapidly. By applying sub-normal heater voltage, a marginal test is obtained that can forecast tube reliability until the next normal service period.

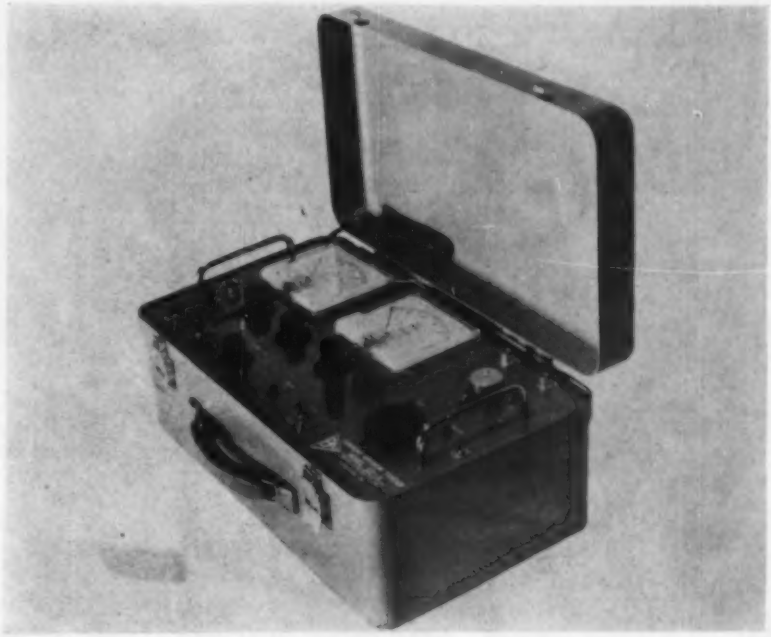


FIG. 1. The current division tester can be used in the service shop or as a part of the maintenance operator's kit.

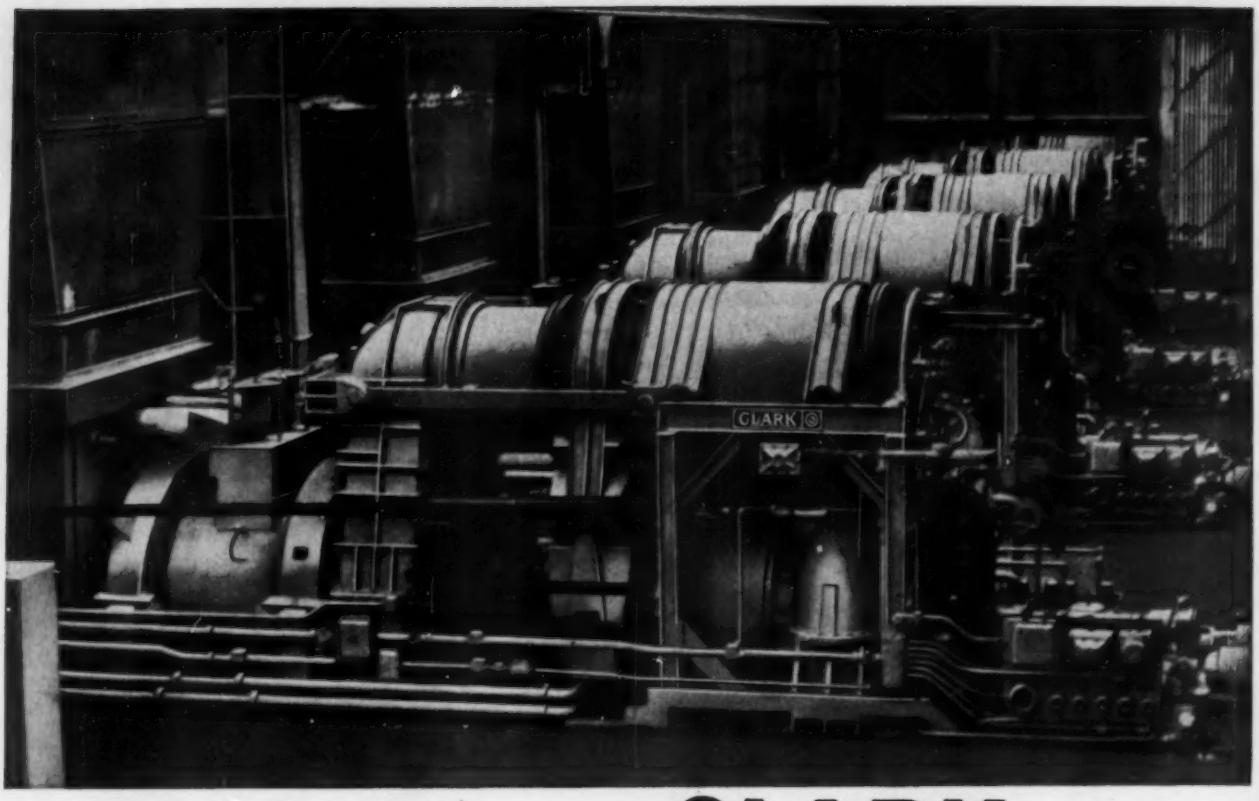
How Test Is Performed

The current division test is performed in this manner: A square pulse is applied to the 2C39 grid. It has a duration of 4500 microseconds and repetition rate of 11 pulses per second. The grid voltage pulse amplitude is adjusted to give a pulsed plate current of 460 ma at the leading edge. This pulse is viewed on a 'scope. Readings are made of pulsed grid voltage and current.

Fig. 2 shows a block diagram of the circuit, with pulse conditions indicated at the several test points.

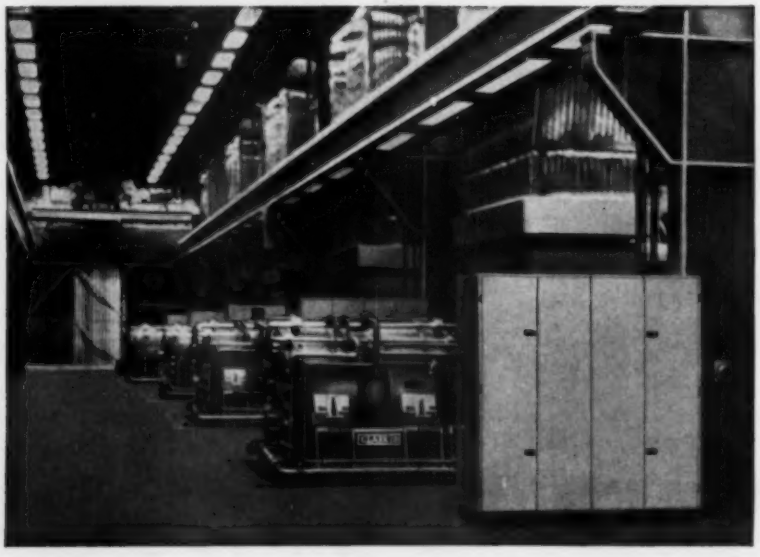
Current division is an important test because it evaluates the transmitting tube, such as 2C39, under the positive grid or Class C conditions similar to actual use. The grid current needed to obtain a specified plate current is indicative of the condition of the tube. Cathode current drain during the long pulse duration shows whether the cathode has sufficient activity to support the plate current needs.

So well does the current division test



Five Clark Model 305 Gas Turbines drive Clark vertically-split centrifugal compressors operating in series. The station is highly automated with only two operators required per shift.

CLARK Gas 210,000,000



In the Arabian Desert...

At 'Ain Dar, Saudi Arabia, five Clark Model 305 Gas Turbines are driving Clark Vertically-Split Centrifugal Compressors for the gas injection program of the Arabian American Oil Company.

Surrounded on all sides by the torrid Arabian desert, the turbines and compressors are installed in a pressurized building to keep out wind driven sand. Available fuel for the turbines is sour gas while ambient temperatures soar to unusually high levels.

The 'Ain Dar injection plant draws gas from five gas-oil separator plants at a pressure of 125 psig, compressing it to 2100 psig for injection. Any four of the five series connected, turbine-driven Clark compressors can provide the necessary pressure ratio for injection. Maximum flexibility is achieved by the use of dual shaft gas turbines. An additional Model 302 turbine drives a 5600 KW generator to power the gas-oil separator plants.

Turbines Power Aramco SCFD Gas Injection Plant

Proved dependability, minimum maintenance and the low installation costs experienced by other users of Clark gas turbines were important factors in selecting the turbines and compressors for the 'Ain Dar plant.

The fact that some of the Clark turbines and compressors could be delivered from the Olean plant and the balance from Italy, was also of prime importance to Aramco.

Clark 305 and 302 gas turbines have a standard rating of 8700-9300 bhp. 1220 bhp. models are also available. Consult your Clark representative for your next gas turbine or centrifugal compressor project or write for descriptive literature.

CLARK

CLARK BROS. CO.
OLEAN, N. Y.
One of the Dresser Industries

COMPRESSORS • GAS TURBINES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

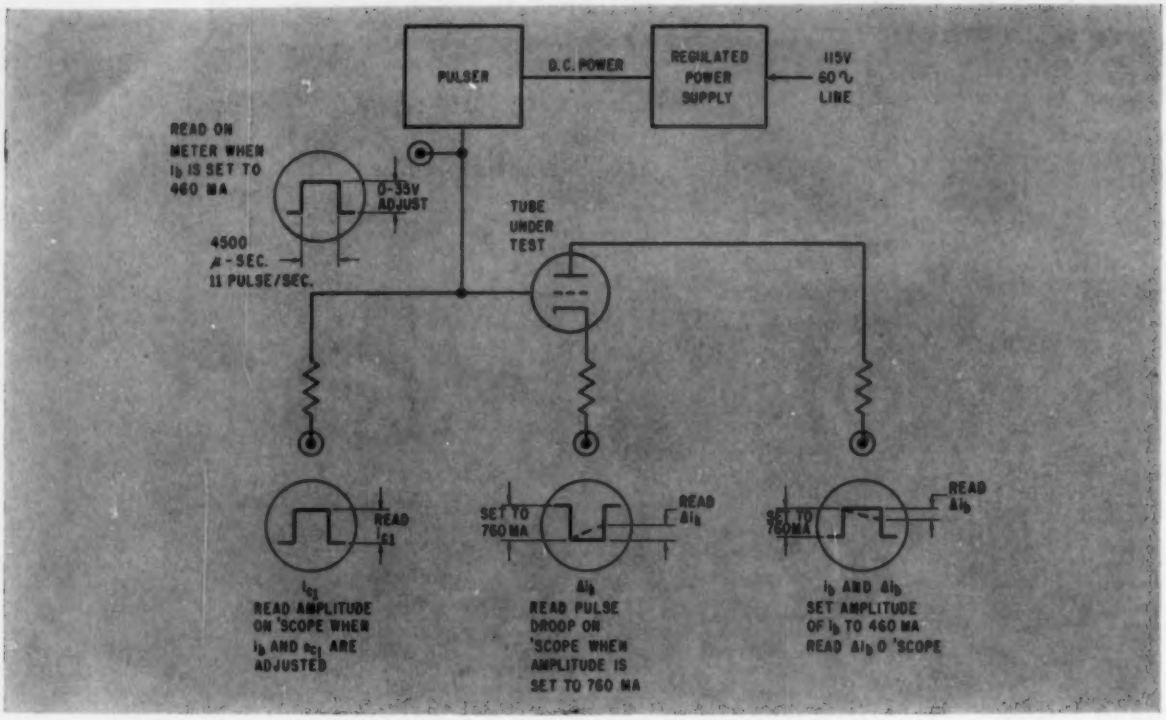

PULSER
D.C. POWER
REGULATED POWER SUPPLY
115V 60 ∿ LINE
READ ON METER WHEN i_b IS SET TO 460 MA
0-35V ADJUST
4500 μ-SEC. 11 PULSE/SEC.
TUBE UNDER TEST
READ e_{c1}
SET TO 760 MA
READ Δi_b
READ Δi_b
i_{c1} READ AMPLITUDE ON 'SCOPE WHEN i_b AND e_{c1} ARE ADJUSTED
Δi_b READ PULSE DROOP ON 'SCOPE WHEN AMPLITUDE IS SET TO 760 MA
i_b AND Δi_b SET AMPLITUDE OF i_b TO 460 MA READ Δi_b O 'SCOPE

FIG. 2. Block diagram of current division test and signals.

evaluate a tube that it has been feasible to omit both plate current and transconductance (Gm) tests from the newest 2C39 specifications.

Pulse emission has long been part of the 2C39 specification. Degree of droop from leading to trailing edge of the pulse is a measure of cathode emission. For rapid evaluation of tubes, however, it is quite acceptable to determine droop during pulsed plate current testing, thus further reducing testing time.

As tubes deteriorate the pulse droop increases, and applied grid pulse voltage increases. Thus, it is easy to establish conditions for tube rejection for any particular tube or transmitter cavity position. It is general practice to place best tubes in the socket having most rigorous requirements. Partially deteriorated tubes may still provide long service life in sockets demanding less from the tube. Using the tester shown in Fig. 1, 2C39 tubes can be measured accurately and selections made to match cavity position. Increased useful tube life and longer operating periods for transmitters result.

In addition to testing for tube geometry and cathode activity, other tube defects are found, such as short circuits, open circuits, arcs, oscillation, and gas and electrical leakage, which are indicated by pulse deformations.

Fig. 3 shows distribution curves for pulsed grid voltage and current for 2C39 tubes. All tubes were new and had just passed conventional new tube specifications. One group had been selected specially because they passed current division limits. The other group was subject to I_b and Gm tests. It is obvious that the least spread in characteristics at operating conditions, as obtained by current division testing, means more uniform transmitter operation, faster optimizing of power output, and higher tube efficiency. Best of all it means shorter servicing time, less transmitter down time, and lower operating costs. ★ ★ ★

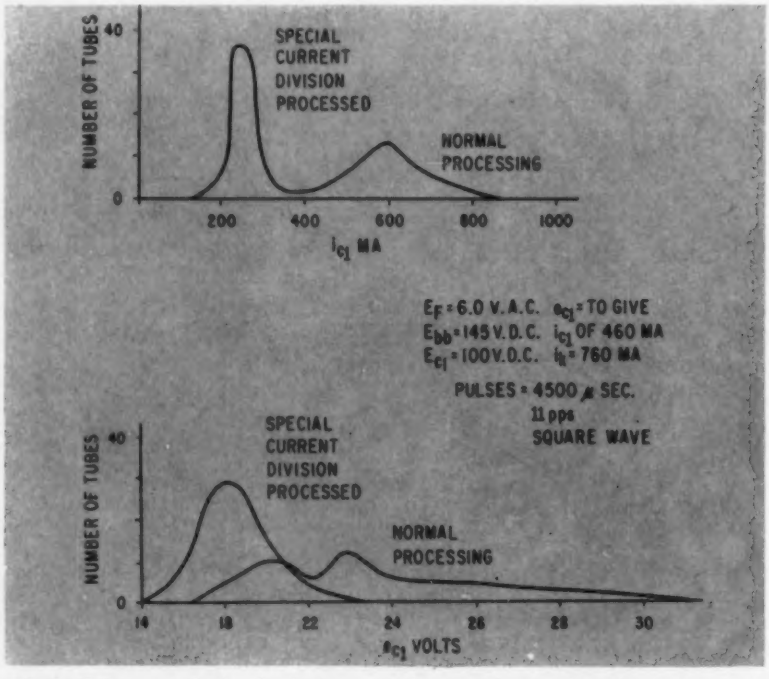


FIG. 3. 2C39 current division distribution curves for new tubes passing mil acceptance tests.

PIPELINE PERSONALS

Rex V. Campbell has announced his resignation as general superintendent of American Louisiana Pipe Line Company to become a consultant in Oklahoma City, Oklahoma. Campbell's career in the gas industry dates back to 1935 when he became associated with Cities Service Gas Company as a machinist. He advanced through various positions with Cities Service and was construction superintendent of compressor stations and dehydration plants when, in 1943, he joined Panhandle Eastern Pipe Line Company as assistant superintendent of compressor stations. In 1949 he accepted a position with Ford, Bacon and Davis, Inc., as assistant superintendent of compressor stations in constructing Michigan Wisconsin Pipe Line. He became superintendent of compressor stations for Michigan Wisconsin, which position he held until transferred to American Louisiana in 1955.

R. V. Campbell

George W. Anders, who has been employed by Texas Gas Transmission Corporation since 1956 as director of public relations, has been appointed to the company's newly created office of director of financial relations. **John R. Blewer** has been appointed to replace Anders as director of public relations. He comes from Bozell and Jacobs, Inc., public relations and advertising counsel to Texas Gas, where he served as manager of financial relations. He also has served as manager of stockholders and community relations for Texas Eastern Transmission Corporation.

Lewis O. Smith has been named manager of compressor and extraction for United Fuel Gas Company and affiliated companies of the Charleston Group. Smith, who previously served as assistant manager of compressor and later assistant manager of both compressor and extraction, will have supervision of over 49 compressor stations, one extraction plant, and three gasoline plants in Kentucky, West Virginia, and Virginia.

William C. Thrailkill, former assistant superintendent of Transcontinental Gas Pipe Line Corporation's gas control department, has been named superintendent of that department succeeding **C. M. Springer** who has gone on an 18-month leave of absence. With Fish Engineering Corporation in Argentina, Springer will organize and train a gas dispatching and control staff composed primarily of citizens of that country.

M. C. Alcorn, manager of pipelines, Pacific Coast, Shell Oil Company, is retiring and will be succeeded by **R. K. Schulze** who has been assistant manager.

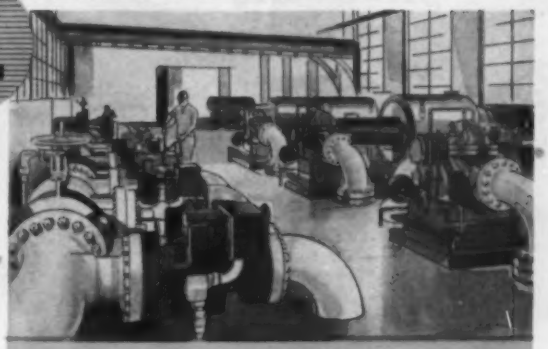
Ralph S. Williams has been named measurement superintendent of Columbia Gulf Transmission Company.

A Solution to Pipeliner Problems

8-B SHAFT SEAL

ON HIGH PRESSURES

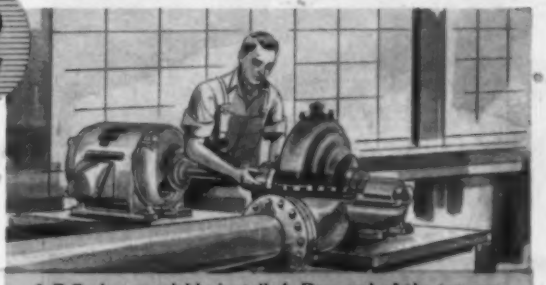
1



Specially engineered hydraulically balanced construction permits handling of all pressures encountered in modern pipe lines. Pipeliners report that 8-B Seals in continuous main line pump service for more than 44,000 hours are still in perfect working condition.

ON MAINTENANCE MAN-HOURS

2



8-B Seals are quickly installed. Removal of the top casing on split case pumps is not necessary. Simply slide the entire unit along the shaft into position. Once installed, little or no attention is required. Service-life is long. No messy leakage.

The 8-B Seal is available in a full range of shaft sizes for every main line or tank farm pump service.

For general information request Bulletin S-215-1. Give mechanical specifications and service details for specific recommendations.

Crane Packing Co., 6486 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). *In Canada. Crane Packing Co., Ltd., Hamilton, Ont.*

John Crane

MECHANICAL PACKINGS · SHAFT SEALS · TEFLON PRODUCTS · LAPPING MACHINES · THREAD COMPOUNDS

CRANE PACKING COMPANY

1st

IN CORROSION PREVENTION

BITUMASTIC
REG. U. S. PAT. OFF
HOT & COLD APPLIED COATINGS

Carey
PIPELINE FELT, PADDING & GLASS PIPE WRAP

TAPECOAT
PIPE JOINT PROTECTION

MAVOR • KELLY COMPANY

M & M BUILDING • HOUSTON • CA 2-2203

6000 1038 4th Street • Gretna, La. • FOrest 1-1861

S. H. Baer

Stephen H. Baer has been appointed to head personnel functions of Pacific Lighting Gas Supply Company in addition to his public relations duties with the company. Baer, whose title will be public relations and employee relations director, joined Pacific Lighting Corporation's storage and transmission subsidiary after heading a news-publications staff of Southern Counties Gas Company.

E. W. Christian

H. R. Rohwedder has been named director of operations for Natural Gas Pipeline Company of America, Peoples Gulf Coast Natural Gas Pipeline Company, and affiliates, succeeding **W. T. Bulla** who has retired. Rohwedder joined the gas transmission firms in 1930 during construction of Natural's Texas-to-Chicago pipeline and has served in a number of supervisory capacities.

E. W. Christian, vice president and general manager of The Imperial Pipe Line Company, Ltd., has been appointed president of The Pipe Liners Club of Western Canada, succeeding **G. J. Evans** who has moved to eastern Canada.

G. A. Peterkin

Alvin M. Hutchison, recently appointed manager of transmission for Ohio Fuel Gas Company, has now been elected a vice president of the company.

George A. Peterkin, chairman of the board of the Houston Contracting Company, has been elected to the board of directors of Falcon Seaboard Drilling Company. Peterkin, formerly associated with Williams Brothers, also is director of Dixie Carriers, Inc., the Texas Fund, Inc., and the Fidelity Bank and Trust Company of Houston.

NEW CORR-PREV TAPE COATING TEAM CUTS PIPE WRAPPING TIME

CHASEKOTE* Polyethylene Tape Coating
CHASEWRAP* Abrasion-Resistant Overwrap

At last! Here's a *one-source* tape coating package that offers all the items needed — including high-speed wrapping machinery — to save time, and save you money! This new CORR-PREV Team also gives you all the corrosion-fighting advantages of time-proved, job-proved *polyethylene* tape. No hot dope mess, drying time or clean-up problems. Half the spread. The result: More footage per day at *lowest applied cost* . . . plus longer lasting pipe protection, with far less cathodic current demand. Want samples, specs, prices? Write CHASE & SONS, INC., 26 SPRUCE ST., NORTH QUINCY, MASS.

(CORR-PREV) DIVISION

*Trade name of Chase & Sons, Inc., long-famous for protective and insulating tapes for electrical wire and cable.

MURPHY

SIMPLEST AUTOMATION YET!

STARTS PUMP AT HIGH LEVEL

Just two $25 liquid level switches do the whole job.

STOPS PUMP AT LOW LEVEL

Write for bulletin DF-588 for details about Model DF-755 . . . or ask for entire catalog.

ANY AUTOMATION IS SIMPLE WITH MURPHY SWITCHES

FRANK W. MURPHY MFR., INC.
BOX 4337 - TULSA, OKLA.
FAR WEST
11812 Davenport Road
Los Alamitos, Calif.

PIPELINE PARADE

. . . in equipment, services, sales

Pipeline Supply Firm Formed

The newly organized M. H. Jackson Pipeline Supply Company has announced it will headquarter at 1017 Gulf Building, Tulsa, Oklahoma, and will commence its initial operations with sales efforts directed to the major transmission and producing companies throughout the country, as distributor representatives of manufacturers of pipeline coatings and wrappings, tape wrappings, pipe beveling machines and pipe handling devices, as well as small diameter API line pipe.

M. H. Jackson

M. H. Jackson is president and chief executive officer; R. B. Wallace is vice president in charge of product sales and new product acquisition and production; and Woodrow Cole is treasurer and office manager.

R. B. Wallace

W. Cole

Plans for formation of a manufacturing division later this year that will permit manufacturing and distributing its own line of equipment for use by pipeline contractors was announced also.

Unit Buys Bay City Shovel

Unit Crane & Shovel Corporation has purchased the stockholdings of Bay City Shovel, Inc., which manufactures cranes, shovels, backhoes, and draglines ranging from ½ to 1½ cu yd as excavators and 10-40 tons as cranes. Operations of the plant at Bay City, Michigan, will continue under the direction of: S. S. Sherman, president; David Emerman, secretary-treasurer; and C. L. Nelson, A. R. Corbett, A. B. Py, W. P. Matschke, and E. F. Rueter, vice presidents.

Sales Engineers Transferred

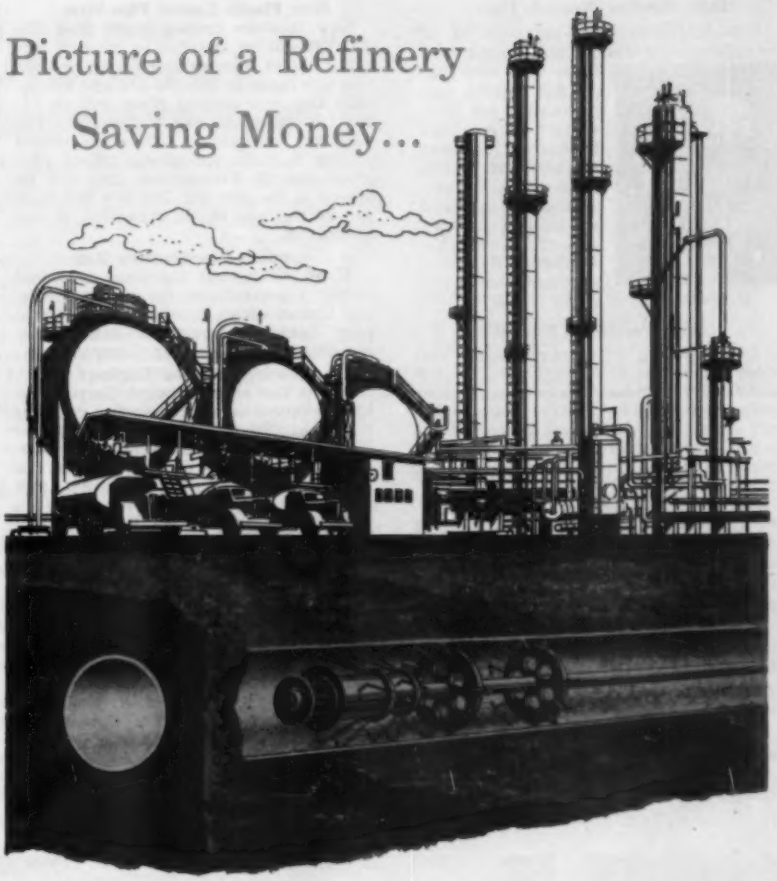
The Cooper-Bessemer Corporation has announced the transfers of several sales engineers most recently assigned to the sales department in Mount Vernon, Ohio. They are: Richard H. Van Bergen, to the New York branch office; David K. Goff, to the Houston branch office; Dressler M. Pruett, to the Tulsa, Oklahoma, district office; R. M. Boone, to the Odessa, Texas, branch office; and David James to the Dallas office.

Owen T. Tolson, most recently with the Foxboro Company, has been named a sales engineer and assigned to the Shreveport, Louisiana, office.

Granco Names Canadian Rep

Granberg Corporation, subsidiary of American Meter Company, announces the appointment of Canadian Meter Company, Milton, Ontario, as official Granco representatives throughout Canada.

Picture of a Refinery Saving Money...



Spunline Relines Pipe Lines In-place without removing the pipe

Another refinery, it could be in Texas, California or Montana, will soon be enjoying the savings of another rehabilitated pipe line. The flow will increase, the pumping cost will drop and the pipe line will be good as new for at least another quarter of a century.

And traffic will move without interruption or inconvenience to the public.

Spunline® is applicable to pipe lines down to 4″ and may be used in cast iron, steel, concrete and wrought iron pipe lines.

Write, wire or phone PIPE LININGS Inc.

Subsidiary of American Pipe and Construction Co.

2414 East 223rd Street, Wilmington, California
P.O. Box 457 • Phones: SPruce 5-3273 — TErminal 5-8201
Rail Address, Pacific Electric, Watson, California

Joins Pipeline Products Firm

Cris Matthews, a 15-year veteran of the pipeline construction and maintenance field, has been appointed district representative for Midwestern Pipe Line Products Company in the states of Oklahoma, Arkansas, northern Louisiana, western Tennessee, western Kentucky, southern Missouri, southern Kansas, and north Texas.

C. Matthews

Vice Presidents Named

Consolidation of manufacturing and sales operations at Kellogg Switchboard and Supply Company has been announced with the formation of three major product departments — central office switching, telephone and transmission, and communication systems — and the establishment of three new executive positions. Named vice president - marketing is Charles J. Trees; Albert F. Cassevant fills the new vice president - communication systems post; Sherman E. Crites becomes vice president - general manager for telephone and transmission.

Richard H. Griebel, formerly manager of manufacturing at Raytheon Company, has been appointed vice president and general manager - central office equipment.

Stuart L. Dunkle, in another Kellogg appointment, was elevated from military automation coordinator to western region manager for government relations.

New Plastic Coated Pipe Sizes

New facilities costing more than $2,000,000 will be installed to increase Republic Steel Corporation's X-Tru-Coat pipe size range to include 6⅝ and 8⅝-in. OD. The new coating plant will be located in the north bay of the 10-in. bar mill in Youngstown, Ohio. Republic's present facilities for plastic coated pipe production at Youngstown also will be moved to the new site. No new buildings will be required in the expansion, it was announced.

Appoints Northeastern Rep

T. W. O'Donnell has been appointed district representative for the northeastern United States by the Parsons Company, trenching equipment manufacturing division of Koehring Company.

Coatings Service Engineer

Reilly Tar and Chemical Corporation has appointed as western service engineer to service coal-tar enamel pipeline coating installations in its southwest and western districts Glen R. Gray, formerly an electrolysis engineer and chief inspector in charge of the coatings laboratory of El Paso Natural Gas Company.

G. R. Gray

Named to Sales Posts

Appointments of James W. Hughes as sales manager of its valve division and C. D. McIntire to succeed him as industrial manager of its Midwest region are announced by Minneapolis-Honeywell Regulator Company.

New Pittsburgh Coke Subsidiary

Pittsburgh Coke & Chemical Company has consolidated its three chemical divisions—activated carbon, protective coatings, and industrial chemicals, and supporting chemical group staff departments—in a new, wholly-owned subsidiary company, Pittsburgh Chemical Company, which plans to spend approximately $7,000,000 for plant expansion this year, including construction of a new plant in the Ohio River Valley near Ashland, Kentucky.

Celebrates 50th Anniversary

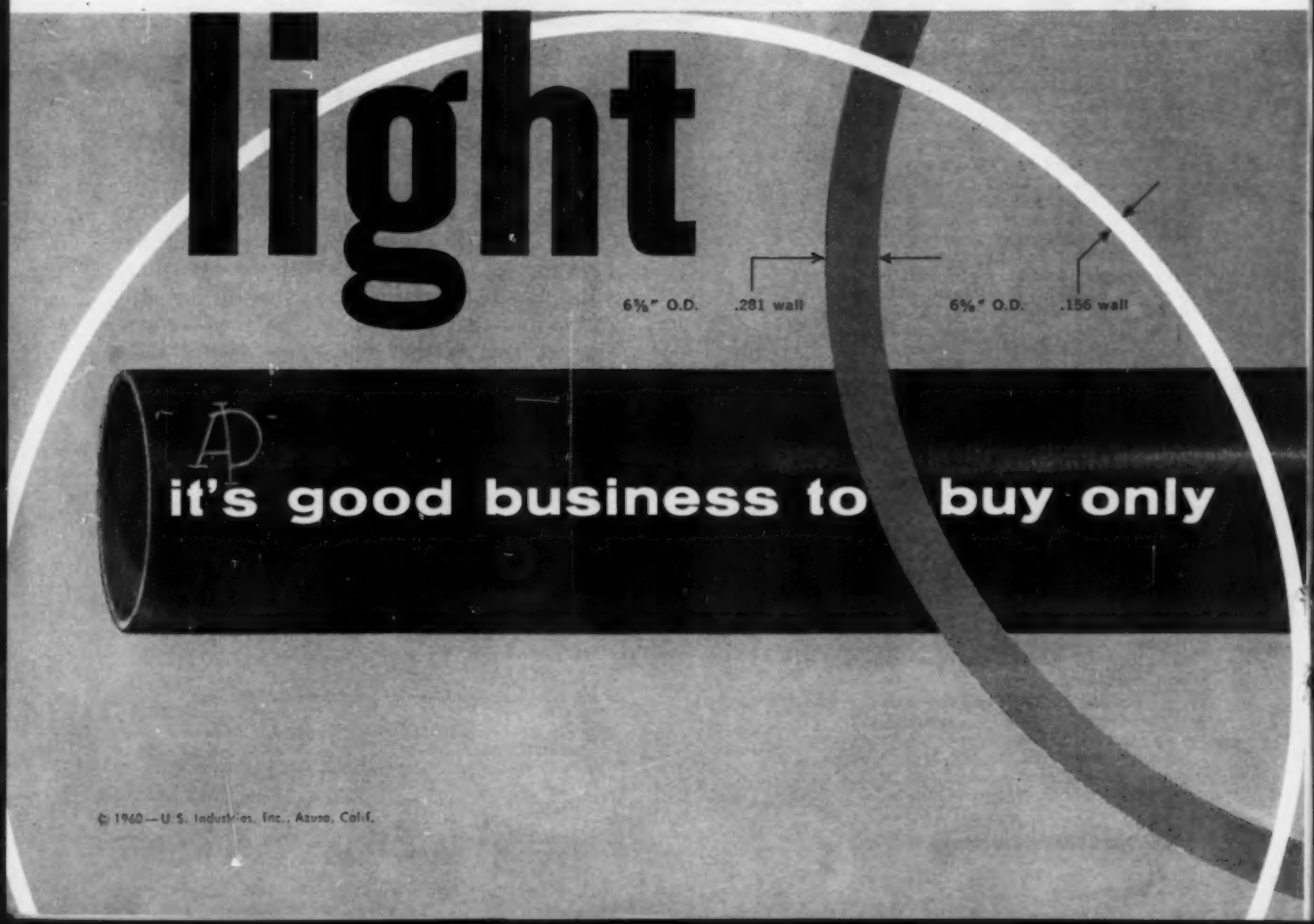
This year marks the 50th anniversary of production at International Harvester Company's Tractor Works. One of five IH manufacturing plants in the Chicago area and one of three comprising the company's construction equipment division, Tractor Works had a small beginning but today consists of 33 buildings on an 82-acre tract.

To Head Foreign Operations

E. A. Smith has been appointed director of foreign operations for Koehring Company, and Vincent R. Peterson has been elected secretary of the company. Smith, vice president and general manager of Koehring Inter-American Company and Koehring Export Division since 1953, replaces F. H. Heine who has retired. Peterson, formerly assistant secretary, replaces P. P. Graser who has retired.

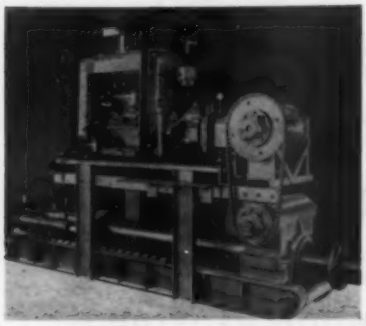
NY District Manager Named

Charles Carter, formerly a sales engineer for Grove Valve and Regulator Company in the company's Houston, Texas, office, has been appointed district manager in the company's New York region.



It's New | Pipeline Equipment

For Under-Road Boring



A new under-road boring machine that bores and installs in one operation 6 to 30-in. casing and 36-in. casing in limited lengths has a 35-hp power unit, with 4-speed transmission and reverse, skid-mounted directly above boring unit and easily removed when desired. This unified construction is reported to facilitate installation of the machine in the pipeline trench and to provide efficient and trouble-free power transmission. Operator has unobstructed vision and full control of boring operation from all sides. *Young Engine Corp.*

Circle number (81) on reply card.

Protective Outer Wrap

A new bitumen-saturated Fiberglas outer wrap which is inert, resistant to impact and soil stress, and not affected by acids and fungus has been announced for the protection of underground pipelines. Designed to cover both hot and cold wrapping applications, it requires no special handling over the usual obstructions, is non-corrosive and unaffected by enamel application temperatures, and may be stored indefinitely without absorbing moisture or otherwise deteriorating. It is available in 2, 3, 4, 6, 9, 12, and 18-in. widths and lengths of 400, 800, and 1000 ft. *Owens-Corning Fiberglas Corp.*

Circle number (82) on reply card.

600-Channel Carrier

A transistorized multiplex-carrier system capable of handling up to 600 voice frequency channels on a single radio beam is of importance to pipeline companies and other users of microwave and cable systems. The new multiplex-carrier's reliability is enhanced by the use of standby component for each component in the common equipment, such as amplifiers and master oscillators. Upon failure of an individual part, the parallel component keeps operating, with no switching delay to seriously affect data transmission. Also claimed is a substantial reduction in power drain. It is of compact, modular design. *General Electric Co.*

Circle number (83) on reply card.

specify LITE-WALL save as much as 33%

Approximately $365,000 in pipeline cost was saved by specifying and buying Southern Pipe LITE-WALL pipe. (Company name on request.) The job called for a 147-mile, 6⅝" petroleum products line. LITE-WALL pipe cut cost by more than ⅓.

It's good business to buy only the steel necessary to do the job. In many cases you needn't buy heavy wall pipe, when Southern's LITE-WALL pipe—available from factory stock—will meet your requirements and afford an ample safety factor.

Southern Pipe pioneered high frequency resistance welding in pipe production.

Southern Pipe offers oil and gas pipe buyers LITE-WALL pipe to cut cost. They also produce line pipe according to API specifications. Sizes range from 3" to 14". Interior and exterior coatings are also available.

Write for SOUTHERN PIPE'S LITE-WALL PACKAGED PIPELINE brochure today.

the steel necessary to do the job—

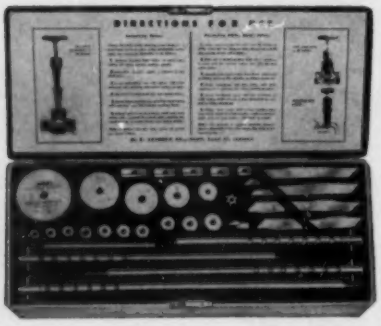
USI

Southern Pipe

DIVISION OF U. S. INDUSTRIES, INC.
P. O. Box C, Azusa, California • CU 3-7111 • ED 7-1221
P. O. Box 1323, Honolulu, Hawaii • Phone 28-5757

SP-6-60

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

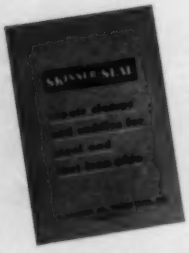
Reseats flat and tapered-seat globe or angle valves—all bibbs and faucets—in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ¼" to 2" valves and ¼" to ¾" bibbs
List price $59.85

3" for ¼" to 3" valves and ¼" to ¾" bibbs
List price $79.50



FREE **catalog showing our pipe repair clamps, saddles, and reseating tools**

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

New Epoxy Resin

A new epoxy resin pipe coating has been introduced that is said to bring the physical and electrical properties of epoxies to the corrosion field at a price that will allow universal use. The one-part powder, "Scotchkote" No. 101, cures in less than 20 sec with close coating tolerances; upon application is completely thermoset and will not flow under pressure or heating; has an adhesion strength of 3000 psi; and resists damage from soil or pipe movement, abrasion and shock of back-filling, and attack by most chemicals, including hydrocarbons. Solvent hazards and post-baking are eliminated. Welding can be accomplished through the 10 mil resin coating, once an arc has been struck on a bared spot. Mill application with portable, inexpensive equipment is a 4-step process — cleaning, heating, coating, and jeeping. In addition to major use as a pipe protection coating, it can be applied to fittings, meter brackets, transformer cases, beams, supports, and other related objects. *Minnesota Mining and Manufacturing Co.*

Circle number (84) on reply card.

"U" Casing Seal

Featuring a fungus and bacteria retardent in the compound and a new "U" design, a new casing seal has been developed that is said to offer "maximum flexibility" that permits crossing installation on wide ranges of coating thickness

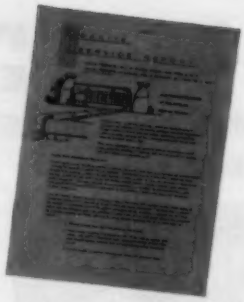
for any given pipe size. It is said to maintain its seal regardless of change in pipe position in relation to casing: up, down, sideways, in or out. Only a screwdriver is needed to tighten the two stainless steel bands that hold the U-Seal in place. The U-Seal can be installed in the new "U" shape with the shorter band "inside" or in the "Z" shape with the shorter band on the "outside." *T. D. Williamson, Inc.*

Circle number (85) on reply card.

Desk-Size Computer

Offering broad use in engineering and scientific calculations, data processing, conversion, logging, and acquisition, and communications systems, is the new Control Data 160 all-transistorized, desk-size electronic computer. It computes in terms of microseconds and can execute 60,000 instructions in one second. It handles data transmissions to and from input-output equipment at speeds of up to 65,000 characters per second. Storage cycle time is 6.4 microseconds. Basic add time is 12.8 microseconds. Information read is available 2.2 microseconds after start of cycle. Average execution time is 15 microseconds per instruction. The 160 uses five megacycle logic. Speed and versatility are realized through its repertoire of 62 instructions and complete programming package. *Control Data Corp.*

Circle number (86) on reply card.



This report helps you save on pump-station maintenance

Here's a new Oakite Service Report — free, of course — on maintenance cleaning at the pipeline pumping station.

It's full of valuable, time-saving ideas ... any one of which might turn out to give you a deep cut in maintenance costs. You'll find helpful shortcuts on:

- Engine room maintenance
- Lube oil cooler maintenance
- Cleaning electric motors, generators, control panels, etc.
- Paint stripping
- Storage tank cleaning
- Cleaning crude and natural gas lines

FREE. Write for a free copy of this Oakite Service Report No. B6878. Address Oakite Products, Inc., 51A Rector Street, New York 6, N.Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

In our 51st year

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Quick-Dry, Red Primer

A new quick-drying synthetic primer for hot coal-tar enamels, featuring a translucent red color that permits visible detection of any areas missed in cleaning, any areas not covered by the primer, and any areas not covered by the enamel, has been announced. Reilly Redhead dries to touch in 5 to 10 min after application to metal surfaces at 70 F where relative humidity does not exceed 70 percent and is ready to accept enamel within 2 hr under the same conditions; is free from organic solvent vapors; has high initial bond strength; features increased life sufficient to protect clean surfaces several weeks if enameling is delayed; and has a coverage rate of 500 to 800 sq ft per gal. *Reilly Tar & Chemical Corp.*

Circle number (87) on reply card.

Cuts Spatter Loss

A new general-purpose, mild steel class E-6012 welding electrode that is said to cut spatter loss up to 60 percent has been developed for heavy or high-speed production welding where fit-up is poor, and the development engineers expect it to reduce materially the large number of rods of its kind, thus simplifying selection

and storage problems of the user. The new rod is said to cut spatter loss so that deposition efficiency is up 15 percent at high currents, increasing crack resistance with a high crowned convex bead and reducing slag removal and cleaning time at least 50 percent. *A. O. Smith Corp.*

Circle number (88) on reply card.

Said To Reduce Costs Of EDP Programming

A system that eliminates endless manual program coding by enabling the computer to translate simple statements in English into its own detailed machine instructions has been announced. This simplified technique for automatically preparing electronic data processing programs is known as FACT (Fully Automatic Compiling Technique) and is designed for use with the Honeywell 800 all-transistorized data-processing system. The programmer, using the FACT system, provides the compiler with a set of simple instructions written in narrative business English which completely describes the program, and FACT then creates the program that does the job. All the machine-oriented problems are solved by the compiler, drastically reducing the programmer's task. *Datamatic Div., Minneapolis-Honeywell Regulator Co.*

Circle number (89) on reply card.

Drying Time Reduced

A new drying agent has been added to "Ospho" metal treatment that, in the average application, reduces drying time to approximately half the 12 hr formerly required. "Ospho" is applied directly on rusted metal to chemically change rust (iron oxide) into iron phosphate, an inert surface that provides a base for regular maintenance paint and a bond between new metal and paint. *Rusticide Products Co.*

Circle number (90) on reply card.

CORROSION CAN COST YOU THOUSANDS OF DOLLARS...

. . . not only in actual losses of damaged pipe . . . but more important, and certainly more costly, is the time and money lost in hunting leaks, excavating lines, cutting out and replacing bad sections, backfilling and cleaning up.

Midwestern products and Midwestern service are aimed at preventing such excessive maintenance. Midwestern's line is selected from the proven leaders in the entire field of anti-corrosion products to provide protection against any type of above or below ground corrosion.

Midwestern's experienced engineering and service organization is available to work with you on any phase of corrosion prevention. A Midwestern Man has the selection of products plus the field training and experience needed to work out the most effective, most economical solution to your corrosion problems. Contact one of the *nine* Midwestern offices for fast action on your technical problems or product shipments.

KERMAC strong, corrosion resistant outerwrap

permanent, high-speed asbestos felt

COROMAT durable, soil stress resistant underground wrap

KAPCO rock shield, tough flexible protection

GLASFAB ideal handwrap for hot spots . . . holidays

Polyken pipe coatings

MIDWESTERN PIPE LINE PRODUCTS CO.

4645 Southwest Blvd. Tulsa, Okla. HI 6-6144

Cable Address: Mid Pipe

branch offices
- Houston, Tex.
- Atlanta, Ga.
- Mt. Prospect, Ill.
- Pittsburgh, Pa.
- Oklahoma City, Okla.
- Des Moines, Ia.
- New York, N.Y. (export)
- Caracas, Venezuela

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Has 46% More Lift

With a total lift capacity of 38,800 lb, the newly-announced Cat No. 561 Series B pipelayer has 46 percent more lift capacity than the predecessor model. It is powered by a compact, 93 flywheel hp engine incorporating a new unit fuel pump housing to permit easier servicing of the entire assembly. Controls permit short, direct arm movements. A special safety feature is the spring loaded boom brake lever that returns automatically to "brake-on" position when released. An inter-lock lever, when engaged, locks the boom drum and holds the boom winch transmission out of lowering gear. Standard boom length is 15 ft. *Caterpillar Tractor Co.*

Circle number (91) on reply card.

NEW Arno

PIPE-WRAP TAPE

Positive Protection for Buried Pipe

Here's pipe protection by the roll. Pipe-Wrap is made of stretchy, inert polyethylene with a pressure-sensitive adhesive to provide a tough, continuous barrier against rust, acids, alkalis and electrolytic currents. Saves time and money.

MANUFACTURERS AGENTS WANTED FOR SOME SELECTED AREAS

SEND FOR FREE SAMPLE

Arno ADHESIVE TAPES, INC.

Dr. Scholl's Adhesive Tape Division

4162 Ohio Street, Michigan City, Indiana

Write for Bulletin

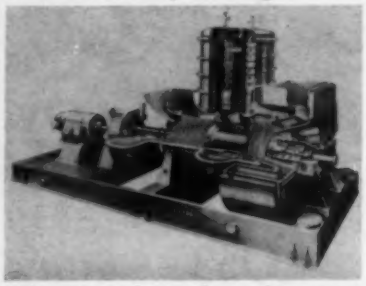
PATENTED

PIPELINE VENTS AND MARKERS

FLEET-LINE CO.

P. O. BOX 276-A
SHREVEPORT
LOUISIANA

Has 9000 Bhp Rating



A compact heavy duty prime mover has been designed to achieve substantial savings in initial equipment cost, transportation, floor space, foundation and installation expense. The new open cycle, 3-stage, single shaft gas turbine with a NEMA rating of 9000 bhp burns either liquid or gaseous fuels and is capable of continuous operation under full load conditions at normal rated speed of 5000 rpm. At rated speed, the axial compressor delivers a mass flow of 135 lb per sec and features horizontally split case and bearing housing for easy maintenance. Turbine inlet temperature is held under 1400 F. Clark's Model 305-S turbine is air cooled. *Clark Bros. Co., one of the Dresser Industries.*

Circle number (92) on reply card.

New Literature

Cost Estimating Guide

Factors necessary for profitable earth-moving and pipelining operations are covered in a 76-page book entitled "Basic Estimating." Beginning with applications of bulldozer, bullgrader, push tractor, and general considerations of tracks versus rubber, the book continues to "estimating hourly production," estimating fixed and operating costs, and production curves on International's line of equipment. Reference data comprise the fifth and final section of the publication which is illustrated with charts, diagrams, tables, and formulae. *International Harvester Co.*

Circle number (95) on reply card.

Advance Station Tests

A unique electronic machine that greatly reduces costly piping alterations at compressor stations on new natural gas pipelines is being used by Worthington engineers. It allows them to create electrical circuit analogies which accurately predict machine and system performance before design and construction are finalized. To prevent harmful vibrations and pulsations, each stroke of the compressor and the length of each piece of pipe must be carefully coordinated — the job of the electrical analog. *Worthington Corp.*

Circle number (93) on reply card.

Small Rotary Meter

A new rotary-type positive displacement gas meter can be flange-mounted directly in either a horizontal or vertical gas line without need for additional support and provides straight-through gas flow. A flow range of 3000 cu ft per hr, combined with a working pressure rating of 125 psig, is intended to adapt this small, 55 lb meter to measurement of many industrial and commercial loads. The permanent and non-adjustable accuracy feature claimed also makes it well adapted to service in remote or unattended locations. *Roots-Connersville Blower Div., one of the Dresser Industries.*

Circle number (94) on reply card.

Explains Control Device

Of special interest to those concerned with message and data communications system design is a new 20-page, 4-color brochure entitled "Teletype 28 Stunt Box" that provides users and potential users of Teletype Model 28 equipment with an understanding of how the page printer and automatic send-receive set can be utilized to the maximum. *Teletype Corp.*

Circle number (96) on reply card.

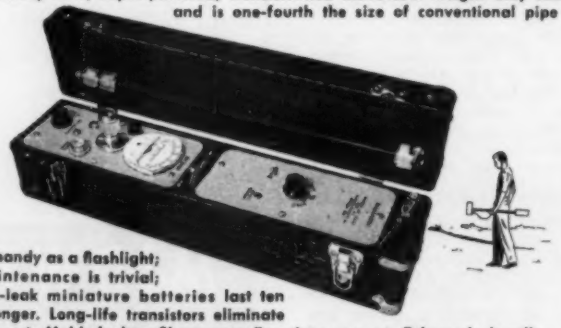
Seismic Analysis

"Ripping With Seismic Analysis," a new 8-page brochure, discusses the principles, method, and operating technique. A table shows the rippability of various materials such as limestone, sandstone, gneiss, caliche, conglomerate, etc. *Caterpillar Tractor Co.*

Circle number (97) on reply card.

The MINIATURIZED-PRECISION WILKINSON Line Locator Model W-3

This radically new, super-powered, transistorized instrument weighs only four pounds and is one-fourth the size of conventional pipe locators.

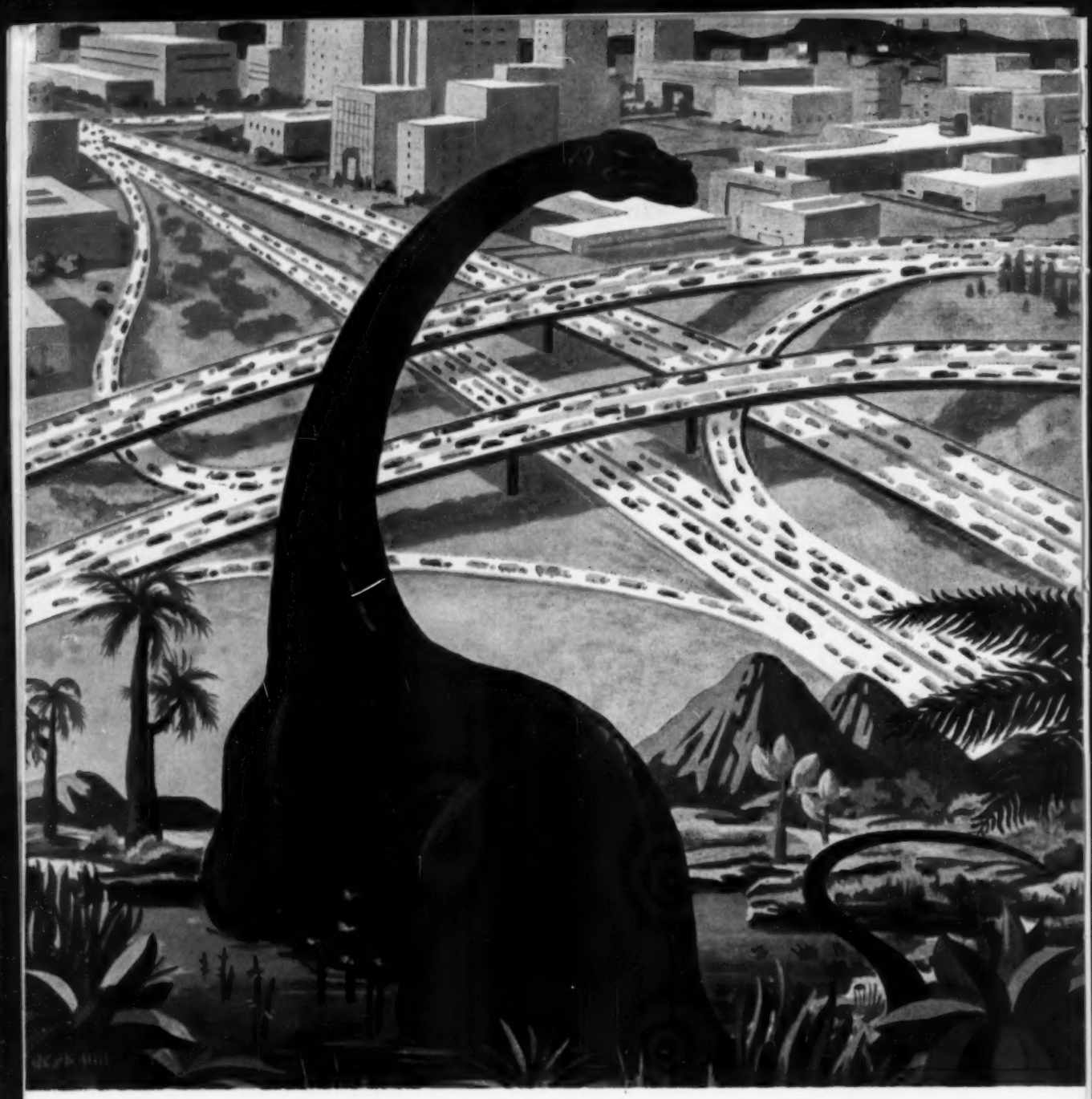


It is as handy as a flashlight; the maintenance is trivial; the non-leak miniature batteries last ten times longer. Long-life transistors eliminate replacement. Molded glass fibre cases. Transistor ear set. Telescopic handle. Etches circuitry and unique antenna. Contained in carrying case.

WILKINSON PRODUCTS COMPANY

3987 Chevy Chase Drive • Pasadena 3, California • SYlvan 0-4314

Modern Logging Services
ELGEN ELECTROLOG
INDUCTION LOG
MINILOG
FOCUSED LOG
TEMPERATURE LOG
CALIPER LOG
NUCLEAR LOG
DENSILOG
CEMOTON LOG
CHLORINILOG
ACOUSTILOG
DIPLOG
CORGUN
You're Ahead with LANE-WELLS!
LANE-WELLS COMPANY
A DIVISION OF DRESSER INDUSTRIES, INC.
P. O. BOX 1407 • HOUSTON 1, TEXAS



FOSSIL FUELS FOR FREEWAYS

The busiest traffic arterial in the world is the Freeway system. Millions of motorists use these Freeway engineering achievements each day, as the most advanced intra-city type of highway system in the free world . . . to work . . . from work, and on business.

Millions of gallons and pounds of petroleum products are consumed each day, used up, ridden on, handled over this traffic artery, *and still the need keeps growing.*

To back up this and other areas of petroleum products consumption is the responsibility of the entire petroleum industry.

"Produce more so we can use more" say 120 million car riding Americans who pay silent tribute each day to the fact that the better way of life stems from petroleum.

Our responsibility to these car riding Americans is, and will continue to be, as a partner of the petroleum industry, to help you find and produce the products this moving traffic world needs and uses.

We'll be here to answer the challenge.

HALLIBURTON OIL WELL CEMENTING COMPANY
DUNCAN, OKLAHOMA